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# PHYSIOLOGICAL STUDIES ON STORAGE LIFE OF APPLE FRUITS

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## ABSTRACT

This study was carried out during two successive seasons of 2000 and 2001 to evaluate the effect of calcium chloride as a post-harvest treatment for keeping quality of Anna apple fruits under 75 days of cold storage at 0°C. The obtained data revealed that, held Anna apples fruit at 10 °C before dipping in $CaCl_2$ solution were effective in reducing the losses in weight than fruits held at 20 °C or the untreated fruits.

Furthermore, this treatment gave more pronounced effect for reducing both losses in weight ; include loss in weight and loss due to decay .Also, this treatment maintained the parameters quality of apples during storage period than the other treatments used. Also, dipping Anna apple fruit at 10 °C in $CaCl_2$ solution at 20 °C presented a higher fruit firmness than other treatments used. Moreover, dipping fruits at 20 °C in $CaCl_2$ was the most effective and permeated higher calcium content than the other treatments used in the tissue of fruits.

## INTRODUCTION

Apple (*Malus sp*) belong to family Rosaceae. It constitute the greatest part of pome fruit production in the recently world. Ministry of Agriculture **(ADS, 1980**) has introduced some low chilling requirement cultivars, such as, Anna, Ein Sheimer and Dorsett Golden. These newly cultivars have much better quality than other locally grown, yet their colour and flavour are not of superior quality compared to those of high chilling requirements.

Anna apple is the leading one of all introduced cultivars, since its trees require about 300-350 hrs below 7.2 °C for breaking their bud dormancy. Fruit is medium to large, skin red cheeked, flesh sub acid to sweet, flavour mild, ripening the end of June to first of July and trees are considered to be regular bearer. The cultivated area of "Anna" apples increased drastically due to high income return per Feddan compared to other deciduous fruits, since it reached about 62710 feddans with an annual total production 468443 tons according to the last statistics in Egypt 2000.

Several investigations were carried out to improve their fruit quality to be more acceptable to consumer (Hyodo, 1991 and Autio and Greene, 1994). No doubt that process of handling and storage for local market and export is essentially important. Also, the extension of marketing period using post-harvest treatments is of vital interest. As a result of increasing the cultivated area of Anna apples, there is a desperate need for studying how to extend the marketing period and how to reduce post-harvest losses. In addition, apple supply is much more than the demand during the harvest period (June and July), Therefore, storage of fruits frequently should be necessarily to supply apple fruits over a long period of time.

The main objective of this investigation is to study the magnitude of calcium chloride effects; which has been found to play an important role in maintaining fruit quality parameters and prolonging the storage life of Anna apple under cold storage conditions.

## MATERIAL AND METHODS

This study was carried out during two seasons of 2000 and 2001 to evaluate the effect of calcium chloride as a post-harvest treatment for keeping quality of Anna apple fruits, 75 days under cold storage at 0°C.

Fruits were picked from trees about eleven -year- old, budded on MM 111 rootstock grown in clay soil and spaced at 4-meters apart in a private orchard at Saft-Trab village near, El-Mahalla El-Kobra,Gharbia Governorate.

Mature apple fruits were picked when the red colour reached over 50%, fruit firmness was about 11-12% according to **Drake and Kupferman (2000**).

The fruits were harvested and transported to the Laboratory of post-harvest Center in Alex. Univ. Agric. College on the first season, and in Pomology Depart., Mansoura Univ. on the second one.

In the beginning, fruits were washed with tap water, air dried, then sorted to remove the infected and damaged fruits, after that divided to seven groups, calcium solutions were prepared with 2% $CaCl_2$ and cooled at 10 or 20 °C. Subsequently, each group where in $CaCl_2$ solution or water for 5 min. to receive one of the following treatments as shown from Table (1):

**Table (1). The applied treatments used:**

| NO | Treatment used |
|---|---|
| 1 | Dipping apple fruit at 20 °C in tap water. |
| 2 | Dipping apple fruit at 20 °C in $CaCl_2$ solution at 10 °C. |
| 3 | Dipping apple fruit at 20 °C in $CaCl_2$ solution at 20 °C. |
| 4 | Dipping apple fruit at 10 °C in tap water. |
| 5 | Dipping apple fruit at 10 °C in $CaCl_2$ solution at 20 °C. |
| 6 | Control (without any treatment) |
| 7 | |

Six boxes for each treatment divided into 3 replicates stored at 0°C to determine losses in weight and decay. Also, chemical changes(total titratable acidity, total anthocyanin and total calcium content) were determined in fruits after 75 days of cold storage.

The experiment was ended as the physiological and pathological disorders of the control reached about 50% of the initial number of the fruits **(**Esmat, 1994).

**1- Loss in weight percentage:**

$$\text{Weight loss \%} = \frac{\text{Initial weight} - \text{weight at sampling date}}{\text{Initial fruit weight}} \times 100$$

**2– Decay percentage :**

$$\text{Decay \%} = \frac{\text{Weight of decayed fruits}}{\text{Initial fruit weight}} \times 100$$

**3- Total losses in weight% :**

It was calculated by adding percentage of loss in fruit weight and decayed fruits as followed :

Total losses in weight % = loss weight% + weigh loss due to decayed fruits t%

**4- Fruit firmness :**

Firmness of 15 fruit was measured by using a hand Eff-gi-penetrometers supplemented with plunger of 11.1 diameters and the average was calculated as Lb/inch$^2$. This plunger size reflects standard method for the respective (Harker *et al.,* 1996).

**5- Total calcium:**

Samples of 0.2 g of dried flesh of fruits were extracted by Neslar solution then filtered, $Ca^{+2}$ determined using Atomic Absorption Spectrophotometer according to the method described by (**Piper, 1958)**.

**6-Soluble solids content (SSC):**

A hand refractometer was used to determine the soluble solids content percentage in fruit juice.

**7- Total titratable acidity:**

Total titratable acidity was determined in fruit juice as malic acid according to (A.O.AC. 1980).

**8- Soluble solids content (SSC) /acid ratio :**

SSC/acid ratio was expressed as the ratio between SSC content and total titratable acidity.

**9- Total anthocyanin content :**

0.5 g from the mixture of fruits skin was homogenized with 10 ml of acidified alcohol solution for 24 hours, centrifuged for 3 minutes, filtrated and then completed to 25 ml with acidified alcohol. The absorbance of extracted anthocyanin were measured at 520 nm using Spectrophotometer according to (Hsia *et al*., 1965).

**Statistical analysis:**

The obtained data were statistically analyzed according to Duncan's method to compare between means as described by **(Snedecor and Cochran, 1980)**.

## RESULTS AND DISCUSION

**1- Losses in fruit weight %** :

The loss in fruit weight of Anna apples during storage are presented in Table (2). The data reveal that, dipping fruits in calcium chloride at 2% significantly reduced the loss in fruit weight compared with the untreated fruits. In this respect, Libaojlang and Fenjun (1995) found that calcium and potassium are important factors in retarding loss in fruit weight during storage. Furthermore, Kalinov *et al.* (1982) presented that calcium application reduced moisture loss by 24 % compared with untreated fruit during 5 months of storage at 0 °C.

On other hand, dipping Anna apples at 10 °C in water only resulted higher percent of loss in fruit weight than the other treatments, but the loss was close to the control. The data also presented that dipping fruits in $CaCl_2$ at 20 °C was more effective for reducing loss in fruit weight than dipping fruits in $CaCl_2$ solutions at 10 °C. Similarly, Mir *et al.* (1993) mentioned that $CaCl_2$ reduced the rate of loss in fruit weight during storage. Furthermore, Abdel-Hameed *et al*. (1996) reported that $CaCl_2$ solution has a measurable influence progressive decrease was observed in weight loss with raising calcium chloride concentration.

**Table (2): Effect of calcium chloride as a post-harvest treatment on weight loss %, decay % and total loss % of Anna apple fruits after 75 days under cold storage seasons 2000 – 2001.**

| Treatment | | weight Loss % | | Decay % | | Total loss % | |
|---|---|---|---|---|---|---|---|
| | | **2000** | **2001** | **2000** | **2001** | **2000** | **2001** |
| **Apples 20°C** | Water | 8.80 | 7.43 | 35.50 | 29.10 | 44.30 | 36.70 |
| | $CaCl_2$ 10°C | 8.33 | 7.30 | 29.86 | 26.13 | 38.20 | 33.43 |
| | $CaCl_2$ 20°C | 7.43 | 5.83 | 28.50 | 24.66 | 35.93 | 30.50 |
| **Apples 10°C** | Water | 8.30 | 7.20 | 27.56 | 29.06 | 35.86 | 36.26 |
| | $CaCl_2$ 10°C | 8.00 | 7.50 | 24.43 | 19.13 | 32.43 | 26.63 |
| | $CaCl_2$ 20°C | 6.36 | 6.90 | 24.76 | 17.86 | 31.13 | 24.76 |
| **Control** | | 9.30 | 8.63 | 35.50 | 34.0 | 44.80 | 42.56 |
| **L.S.D. at 5 %** | | **0.24** | **0.27** | **0.40** | **0.91** | **0.64** | **1.23** |

**2- Decay percentage:**

It is clear from Table (2) that dipping Anna apple in $CaCl_2$ solution at 10 or 20 °C reduced decay percentage significantly than dipping in water or untreated fruits during cold storage. Furthermore, dipping apple at 10 °C in $CaCl_2$ at 10 or 20 °C reduced decay percentage than when dipping apple at 20 °C in the same solution of $CaCl_2$. Yet, dipping Anna apples in water also reduced the decay percentage than the untreated fruits. Since, the decay percentage of the untreated was a bout 15.5 %.

Likewise, Conway *et al.* (1992) and Sams *et al.* (1993) mentioned that calcium application are necessary to reduce significantly decayed fruits usually in higher concentration than can be obtained by standard fertilization practices. Furthermore, Perring and Pearson (1987) stated that the injection of 1 and 2 % $CaCl_2$ solution at harvest reduced the incidence of bitter pit in the stored fruit from 32 to 16 and 5 % respectively.

Reducing the percentage of decayed fruits during storage by calcium application may be due to the effect of this rephrase the fruits became susceptible to decay, and thus prolonging the storage life. Calcium role were confirmed in several studies on apple fruits Rease (1989).

Also, Park and Lee (1996) and Janisiewicz *et al.* (1998) found that increase $Ca^{++}$ in apple mesocarp reduced disease severity .On the other hand, Eksteen *et al*. ( 1997) dipped Cox's Orange Pippin, Golden Delicious and White Winter Permian fruits in $CaCl_2$ solution at 2 or 4 %, followed or not by rinsing with water after 30 minutes , and stored at -0.5°C for 3.5 and 6 months, found that, the incidences of storage bitter pit was reduced by most treatments.

**3- Total loss in weight % :**

Total loss included loss in fruit weight and decay percentage are presented in Table (2). From these data, it is clear that dipping Anna apple fruits in $CaCl_2$ at 2% reduced the total loss in weight than dipping in water only or the untreated fruit. Since, Marschner (1995) presented that calcium application reduced fruit respiration rate and ethylene production in $Ca^{+2}$ treated fruit. Furthermore, their effect on membrane fluidity, cellulose associated with senescence and decreases the incidence of certain physiological disorders.

Dipping Anna apple fruit at (10 °C) in $CaCl_2$ at (10 °C) or (20 °C) reduced the total loss in weight compared with dipping apple (20 °C) in the same solutions of $CaCl_2$. That is may be due, that held Anna apple fruits at (10 °C) before dipping fruits in $CaCl_2$ was more effective in reducing the total loss in weight. That is not strange, since these treatments reduced both loss in weight and decay percentage than dipping fruit in water or the untreated fruits. In this respect, Scott and Wills (1975) reported that the amount of water taken up by Jonathan and Cox's Orange apples was increased when the temperature of the water was lower than that of the fruit.

Moreover, dipping apples at calcium application solution reduced the total losses in weight than the control. Since, dipping apple at 20 °C in $CaCl_2$ gave lower total losses percentage than the other treatment or the untreated fruits. Furthermore, dipping apple at 10 °C in water presented a higher total loss than dipping apple at 20 °C in water or the control. That is may be due to the temperature of apple which was more effective in this respect.

**4- Fruit firmness and calcium content:**

From Table (3) it is clear that the effect of $CaCl_2$ application on fruit firmness was not pronounced during the two seasons under the study. Yet, the loss in fruit firmness was more clear on the untreated fruits during cold storage.

Whereas, dipping Anna apple fruit at 10 °C in $CaCl_2$ solution at 20 °C presented a higher fruit firmness than other treatments used. Yet, the untreated fruit gave a lower fruit firmness during both seasons under the study.

In this respect, Conway and Sams (1983) reported that the breakdown of pectic substances in the middle lamellae and cell walls, and the loss of cell- wall integrity, may be a key step in the initiation of many of the changes that occur during the fruit – ripening process. Pectin esterase (PE) and Polygalacturonase (PG) are the major enzymes that cause the breakdown of pectic substances and fruit firmness. Hence, Bantash and Arasimovich (1989) noticed that $CaCl_2$ treatment inhibited fruit softening and extended storability.

**Table (3): Effect of calcium chloride as a post-harvest treatment on firmness (lb/inch²) and calcium content of Anna apple fruits after 75 days under cold storage seasons 2000 –2001.**

| Treatment | | Firmness (lb/inch²) | | | | Calcium content % | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Season 2000 | | Season 2001 | | Season 2000 | | Season 2001 | |
| | | Storage period in days | | | | | | | |
| | | 0 | 75 | 0 | 75 | 0 | 75 | 0 | 75 |
| **Apples 20°C** | Water | 9.33 | 5.96 | 9.66 | 6.40 | 0.353 | 0.073 | 0.340 | 0.073 |
| | $CaCl_2$ 10°C | 9.33 | 5.86 | 9.66 | 6.30 | 0.353 | 0.090 | 0.340 | 0.086 |
| | $CaCl_2$ 20°C | 9.33 | 6.26 | 9.66 | 6.50 | 0.353 | 0.143 | 0.340 | 0.146 |
| **Apples 10°C** | Water | 9.33 | 5.50 | 9.66 | 5.83 | 0.353 | 0.073 | 0.340 | 0.036 |
| | $CaCl_2$ 10°C | 9.33 | 5.26 | 9.66 | 6.13 | 0.353 | 0.060 | 0.340 | 0.080 |
| | $CaCl_2$ 20°C | 9.33 | 5.56 | 9.66 | 6.06 | 0.353 | 0.116 | 0.340 | 0.133 |
| **Control** | | 9.33 | 5.00 | 9.66 | 6.00 | 0.353 | 0.030 | 0.340 | 0.066 |
| **L.S.D. at 5 %** | | **-** | **0.28** | **-** | **0.25** | **-** | **0.01** | **-** | **0.02** |

The obtained results could be explained by Marchner (1995) which found that calcium has a vital role in the metabolic regulation especially when present in adequate amounts in the fruit. Since, calcium in plant reducing degradation of the middle lamella.

It can be observed from data in Table (3) dipping fruits at 20 °C in $CaCl_2$ at 20 °C was the most effective and produced higher calcium content than the other treatments used.

The data also reveal that no significant difference in calcium content had obtained during storage with dipping Anna apple fruits at 10 °C in $CaCl_2$ solution at 10 or 20 °C during the two seasons. In this respect, Choi and Lee (1995) observed that calcium content in the peel, flesh and core of apple was increased with the increasing the storage period. The calcium in the peel and core was gradually translocated into the flesh during storage and the majority of this calcium was physiologically active. Whereas, the untreated fruits gave a lower calcium content than those dipping in water or $CaCl_2$ during the two seasons under the study.

That is not strange since, the untreated fruit gave a higher losses and decayed fruit during storage than dipping in $CaCl_2$ application. That is mainly due to the losses in calcium content. Also, Park and Lee (1996) noticed that the concentration of ca in peel and flesh of fruits were increased with post harvest $CaCl_2$ treatments.

In this respect, Conway *et al*. (1993) founded a close correlation between calcium content of stored fruits and pathological disorders. So, when apple fruit were pressure infiltrated at harvest with varying amounts of calcium chloride solution in both total and cell wall bound calcium of the fruit tissue greatly increased.

Furthermore, changes in calcium concentration resulting from dipping fruit in a solution of $CaCl_2$ were markedly influenced by fruit size. The greater increase occurring in small fruit may be explained at least partly by geometry, small fruit has a greater surface to volume ratio than larger fruit and hence they provides relatively more Ca for absorption into the tissue.

**5- SSC % and total acidity in fruit juice:**

It is clear from Table (4) that soluble solids content gradually increased as storage period prolonged. In this respect Adel- Hammed *et al*. (1996) reported that, the soluble solids content of Anna apples fruits was gradually increased according to the extension of the storage period.

**Table (4): Effect of calcium chloride as a post-harvest treatment on on SSC % and total acidity in juice of Anna apple fruits after 7 days under cold storage seasons 2000 –2001.**

| Treatment | | SSC % | | | | Total acidity % | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Season 2000 | | Season 2001 | | Season 2000 | | Season 2001 | |
| | | Storage period in days | | | | | | | |
| | | 0 | 75 | 0 | 75 | 0 | 75 | 0 | 75 |
| Apples 20°C | Water | 11.0 | 12.30 | 11.83 | 13.00 | 0.675 | 0.469 | 0.680 | 0.440 |
| | $CaCl_2$ 10°C | 11.0 | 12.33 | 11.83 | 13.40 | 0.675 | 0.479 | 0.680 | 0.470 |
| | $CaCl_2$ 20°C | 11.0 | 12.76 | 11.83 | 12.70 | 0.675 | 0.506 | 0.680 | 0.515 |
| Apples 10°C | Water | 11.0 | 12.60 | 11.83 | 13.10 | 0.675 | 0.448 | 0.680 | 0.442 |
| | $CaCl_2$ 10°C | 11.0 | 12.70 | 11.83 | 13.20 | 0.675 | 0.506 | 0.680 | 0.457 |
| | $CaCl_2$ 20°C | 11.0 | 11.73 | 11.83 | 13.00 | 0.675 | 0.452 | 0.680 | 0.466 |
| Control | | 11.0 | 12.00 | 11.83 | 12.76 | 0.675 | 0.490 | 0.680 | 0.544 |
| L.S.D. at 5 % | | - | 0.30 | - | 0.18 | - | 0.019 | - | 0.011 |

Concerning the effect of dipping Anna apple fruit in $CaCl_2$ solution at 10 or 20 °C, no clear effect had shown in soluble solids content. Furthermore, Chang and Byuin (1992) found that calcium application had no significant changes on fruit soluble solids contents during cold storage.

From Table (4) the data presented that total acidity in fruit juice was gradually decreased as storage period advanced. In this respect, Primoradian and Bablar (1995) found that titratable acidity was not affected by $CaCl_2$ concentration. Similarly, Noor *et al. (*1994) showed that total acidity during cold storage was reduced with increasing the concentration treatments of calcium chloride. Similar information was presented by Raese and Drake (1993). With regard the effect of dipping Anna apple fruit in $CaCl_2$ solutions, no clear effect had noticed due these treatments.

Since, the losses in total acidity in juice fruits were unpronounced during cold storage.

Abdel–Hammed *et al*. (1996) found that acidity in the pulp of the fruits was increased especially with the higher rate of calcium chloride and prolonging storage duration substantially raised all the studied parameters except total acidity.

**6- SSC/ acid ratio in juice and total anthocyanin content on apple fruit:**

Considering to the effect on SSC/acid ratio, data in Table (5) reveal that the increment in soluble solids/acid ratio during the storage period may be due to the reduction attributed in total acidity with the increment in soluble solid / acid ratio in fruit juice.

**Table (5): Effect of calcium chloride as a post-harvest treatment on SSC/ acid ratio and anthocyanin content of Anna apple fruits after 5 days under cold storage seasons 2000 –2001.**

| Treatment | | SSC/ acid ratio | | | | Anthocyanin (OD) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Season 2000 | | Season 2001 | | Season 2000 | | Season 2001 | |
| | | Storage period in days | | | | | | | |
| | | 0 | 75 | 0 | 75 | 0 | 75 | 0 | 75 |
| Apples 20°C | Water | 16.23 | 26.20 | 17.33 | 29.50 | 1.426 | 0.497 | 1.400 | 0.555 |
| | $CaCl_2$ 10°C | 16.23 | 25.53 | 17.33 | 28.50 | 1.426 | 0.610 | 1.400 | 0.500 |
| | $CaCl_2$ 20°C | 16.23 | 26.06 | 17.33 | 24.73 | 1.426 | 0.639 | 1.400 | 0.640 |
| Apples 10°C | Water | 16.23 | 28.06 | 17.33 | 29.60 | 1.426 | 0.543 | 1.400 | 0.710 |
| | $CaCl_2$ 10°C | 16.23 | 25.13 | 17.33 | 29.00 | 1.426 | 0.656 | 1.400 | 0.830 |
| | $CaCl_2$ 20°C | 16.23 | 25.93 | 17.33 | 28.10 | 1.426 | 0.623 | 1.400 | 0.800 |
| Control | | 16.23 | 24.46 | 17.33 | 23.40 | 1.426 | 0.500 | 1.400 | 0.805 |
| L.S.D. at 5 % | | - | 0.77 | - | 0.64 | - | 0.032 | - | 0.054 |

That is not astonishing since, the increment in soluble solids content during the storage period was due to the conversion of starch to sugars under cold storage.

Regarding to the effect of $CaCl_2$ solution, the data presented that no clear effect had obtained in this respect. Abdel–Hammed *et al.* (1996), reported that, the soluble solid / acid ratio in Anna apples juice was increased gradually as storage period advanced.

Concerning the changes in soluble solid / acid ratio, data revealed that this ratio was increased with the storage period advanced under cold storage. Furthermore, Anzueto and Rizvi (1985) presented that a general decline in soluble solids (total sugars) was observed in apple fruit and this decline was associated with starch degradation. Also, Burton (1978), the role of the reduction in sugar content during the storage period, may be due to reduction in respiration rate and metabolic processes. Also, acidity tended to decline at the end of the storage period, Temperature appeared to be the most factors critically affecting acid loss of the fruit.

It is clear from Table (5) that anthocyanin content was gradually reduced as the storage period advanced. These results are in agreement with Adel-Wahab (1986) which found that the concentration of anthocyanin and flavones increased during storage. So, the changes in anthocyanin content were sharply after one month during storage.

Calcium chloride application gave somewhat increment in anthocyanin content of Anna apple fruits than those treated with water only or the untreated fruits. Since, Forkmann (1991) indicated that red skin color is directly related to the anthocyanin concentration and molecular substitution. The effect of calcium chloride on anthocyanin content of Anna apple which dipping in solution of $CaCl_2$ at 10 or 20 °C fluctuated during the two seasons. Since, no significant effect has obtained in anthocyanin content under calcium application. Furthermore, Cheng *et al.* (1999) characterized the red color development and the kind of pigments in red fruit were studied. Bagging induced skin color to changes from yellow or green to red. This change was due to a decrease in non red cultivars was not as susceptible to light as that of red cultivars and only began to increase on the 16th days after bag removal.

With the effect of $CaCl_2$ application on the loss of total anthocyanin in apples fruit during storage there is clear effect had obtained between dipping in water and the untreated fruits.

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## دراسات فسيولوجية على تخزين ثمار التفاح

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أجريت هذه الدراسة خلال موسمي ٢٠٠٠ ـ ٢٠٠١ على ثمار التفاح صنف الآنا لتقييم نقع الثمار فى محلول كلوريد الكالسيوم بعد الحصاد للحفاظ على جودة الثمار تحت ظروف التخزين البارد لمدة ٧٥ يوم علي درجة الصفر المئوي.

من خلال هذة الدراسة فأنة يمكن التوصية بأن معاملة ثمار التفاح بخفض درجة حرارته إلى ١٠ درجة مئوية ثم نقعها في محلول كلوريد الكالسيوم ٢ % درجة حرارتة١٠ ,٢٠ درجة مئوية يؤدي الي خفض الفقد الكلي في الثمار خلال فترة التخزين البارد عن معاملة ثمار التفاح بخفض درجة حرارتها الي ٢٠ درجة مئوية أو تلك الثمار الغير معاملة إذ أن هذة المعاملة أدت لخفض كلا من الفقد في الوزن و كذا نسبة الثمار التالفة .

بالإضافة لما سبق فان هذة المعاملة كان لها أثرا واضحا في المحافظة علي خصائص ثمار التفاح خلال فترة التخزين ,بينما نقع ثمار التفاح بعد خفض درجة حرارته إلى ١٠ درجة مئوية في محلول كلوريد الكالسيوم ٢ % درجة حرارتة٢٠ درجة مئوية يؤدى لارتفاع معنوي فى صلابة الثمار, فى حين خفض درجة حرارة التفاح إلى ٢٠ درجة مئوية في محلول كلوريد الكالسيوم ٢ % درجة حرارتة٢٠ درجة مئوية كان أكثر تأثيرا على زيادة محتوى الثمار من الكالسيوم مقارنه بباقي المعاملات المستخدمة.