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EFFECT OF POST HARVEST TREATMENTS WITH CALCIUM CHLORIDE ON STORAGE OF ANNA APPLE FRUITS

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ABSTRACT

The present study was carried out during the seasons of 2005 and 2006 to evaluate the effect of calcium chloride at different concentrations on storage and fruit quality of Anna apple fruits and its changes during cold storage. From this study, it is clear that dipping Anna apple fruits in solution of $CaCl_2$ at 3 % reduced the total loss in fruit weight considerably than dipping at 2 or 4 %. Yet, $CaCl_2$ at 5 % presented a higher total loss in fruit weight than the other concentrations and the control. Moreover, both fruit firmness and Anthocyanin content were reduced with storage period advanced from harvest till 60 days under cold storage. Yet, $CaCl_2$ application gave a higher values of both parameters at harvest and during cold storage. Also, TSS/acid ratio in fruit juice was increased as a storage period advanced but the effect of calcium chloride gave unpronounced effect in this respect.

INTRODUCTION

Apple (*Malus* sp.) constitutes the greatest part of pomes fruit production in the world. Agriculture Development System Project (1982) has introduced to Egypt some low chilling requirement apple cultivars such as Anna, Ein Sheimer and Dorestt Golden. In this respect, Anna apple cultivar is considered one of the leading variety in Egypt. Since, it need about 300 - 350 hr below 7.2 ^{o}C to break their bud dormancy. The cultivated area of Anna apples increased especially in the new land due to high income return per feddan compared to the

other deciduous fruits, since, it reached about 60,585 Fadden with an total production 578,249 ton according to the last statistics in Egypt 2006.(Annual Reports of Statistical and Agric. Econom. Res. 2006)

As a result of increasing the cultivated area of apples, there is a desperate need for studying how to reduce loss of fruits. In addition, apple supply is much more than the demand during the harvest period, therefore storage of fruits is necessary to supply apple fruits over a long time. Cold storage is one of the methods which improving fruit quality through marketing. Several compounds have been used as a pre-harvest treatment to control fruit disorders and prolonged storage life of apple. In this respect, calcium application is one of the most treatments which has been used to reduce decay and loss in weight through its effect on fruit firmness (Conway *et al.* 1992 and Fallahi *et al.* 1997).

The main objective of this investigation is to study the effect of calcium chloride under different concentrations as a postharvest treatment to control decayed fruit in order to supply marketing with good fruit for a long time.

MATERIALS AND METHODS

This study was undertaken during the two successive seasons of 2005 and 2006 on Anna apple fruits to evaluate the effect of calcium chloride at different concentrations as a postharvest treatment to select the suitable concentration which used to keeping quality of Anna apple fruits during cold storage.

Fruits were harvested when the red colour reached over 50 % and fruit firmness was about 11-12 pound /inch^2 according to (ADS, 1982). The fruits were taken and transported to the Laboratory of Pomology Dept. in Mansoura Univ. Therefore, samples of about 20 fruit replicated three times were taken to determine fruit characters at the beginning of storage.

Fruits were sorted to remove any damaged and infected fruits, then washed with tap water, air dried and divided to five groups to carry out the following treatments:

Effect of calcium chloride on storage of anna apple fruits

1- Control (dipping in tap water for 5 minutes) .
2- Dipping in calcium chloride 2 %.
3- Dipping in calcium chloride 3 %.
4- Dipping in calcium chloride 4 %.
5- Dipping in calcium chloride 5 %.

Dipping of fruits in $CaCl_2$ was conducted for five minutes. Thirty boxes for all treatments, 6 boxes for each treatment were stored at 0±1°C. Three boxes for each treatment were taken monthly intervals to determine loss in fruit weight, decayed fruits %, total loss in fruit weight and changes in fruit physical and chemical properties under cold storage :

A- Physical changes in fruits :
1- Loss in fruit weight.
2- Decay percentage.
3- Total loss in fruit weight.
4- Fruit firmness : it was measured by using hand Eff-gi penetrometers supplemented with plunger of 11.1 diameter according to (Harker *et al.*, 1996).

B- Chemical changes in fruits :
1-Total Soluble solids content (T.S.S.).
2- Total titratable acidity (A.O.A.C 1980).
3- Total Soluble solids/acid ratio.
4- Total Anthocyanin : it was measured at 520 nm using Spectrophotometer according to (Hisia *et al.* 1965).

C- Statistical analysis :
This factorial study (A and B factors) was designed by using complete randomized design as described by Snedecor and Cochran ,(1980).

Differences among treatment means were statistically analyzed by using the least significant differences test (LSD) at 5 % level of probability.

RESULTS AND DISCUSSION

1- Effect on loss in weight :

Total loss in fruit weight is including loss in fruit weight due to loss in weight and decayed fruit during cold storage at 0±1 °C.

Loss in fruit weight % :

Data from Table (1) showed that, the loss in fruit weight was gradually increased as the storage period prolonged. The data also reveal that dipping Anna apple fruit in Calcium chloride at 2, 3 or 4 % solution reduced the values of loss in weight during storage. Yet, calcium chloride at 2 % gave a lower values of loss in weight. Thus, treated fruits with $CaCl_2$ at 5 % gave a higher loss in fruit weight % compared with the other concentrations during both seasons. In this respect, Libaojlang *et al.* (1995) mentioned that calcium are important factors in retarding loss in fruit weight. Also, Mir *et al.* (1993) reveal that $CaCl_2$ reduced the rate of loss in fruit weight during storage. Also, Hussein *et al.* (2001) mentioned that $CaCl_2$ at 4 % was the most effective to minimize loss in fruit weight and decay percentage and recorded the highest values of fruit firmness than 2 % during storage period. Furthermore, El-Eryan (2002) presented that dipping Anna apple fruits in calcium chloride at 2 % reduced the loss in fruit weight significantly than the control.

Table 1 : Effect of Calcium application on percentage of Loss in weight of Anna apple fruits under cold storage.

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage (B)					
	0	30	60	0	30	60
Control	0.00	3.81	4.99	0.00	4.00	5.85
$CaCl_2$ 2%	0.00	2.18	3.71	0.00	3.03	4.91
$CaCl_2$ 3%	0.00	3.08	4.60	0.00	2.23	4.74
$CaCl_2$ 4%	0.00	3.15	4.94	0.00	2.58	4.13
$CaCl_2$ 5%	0.00	4.56	5.37	0.00	4.20	5.52
L.S.D at 5%	Treatment A : 0.202 Storage period B : 0.157 Interaction B : 0.350			Treatment A : 0.229 Storage period B : 0.177 Interaction B : 0.396		

2- Decay percentage :

It is obvious from Table (2) that both calcium chloride at 3 or 4 % reduced the percent of decayed fruit significantly than those obtained from 2 or 5 % and control. Since, these treatments gained about 12.4 and 13.4 % after 60 days under cold storage. Yet, calcium chloride at 5 % gave a higher decayed fruits, so it presented about 19.0 % decayed fruits at the same period as a mean of two seasons. These results could be explained that cell wall which help in maintaining fruit firmness to resist decay (Conway *et al.* 1992). Also, calcium induced resistance to post-harvest pathogens which has been attributed to an interaction between certain components and Ca ions (Conway *et al.* 1994).

Table 2 : Effect of Calcium application on Decay % of Anna apple fruits under cold storage.

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage (B)					
	0	30	60	0	30	60
Control	0.00	8.63	15.11	0.00	7.76	18.11
$CaCl_2$ 2%	0.00	10.30	15.85	0.00	9.43	16.28
$CaCl_2$ 3%	0.00	7.51	10.84	0.00	7.91	14.05
$CaCl_2$ 4%	0.00	9.88	14.52	0.00	7.46	12.32
$CaCl_2$ 5%	0.00	12.00	18.95	0.00	12.50	19.00
L.S.D at 5%	Treatment A : 0.428 Storage period B : 0.332 Interaction B : 0.741			Treatment A : 0.441 Storage period B : 0.342 Interaction B : 0.674		

3- Total loss in fruit weight :

Total loss in fruit weight is mainly due to loss in fruit weight and decayed fruits are presented in Table (3), from this Table it is clear that dipping Anna apple fruit in calcium solution at 3 or 4 % reduced the percentage of total loss.

Table 3 : Effect of Calcium application on percentage of Total loss of Anna apple fruits under cold storage.

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage (B)					
	0	30	60	0	30	60
Control	0.00	12.44	20.10	0.00	11.76	23.96
$CaCl_2$ 2%	0.00	12.48	19.56	0.00	12.46	21.19
$CaCl_2$ 3%	0.00	10.59	15.44	0.00	10.14	18.79
$CaCl_2$ 4%	0.00	13.03	19.46	0.00	10.04	16.45
$CaCl_2$ 5%	0.00	16.56	24.32	0.00	16.70	24.52
L.S.D at 5%	Treatment A : 0.487 Storage period B : 0.378 Interaction B : 0.845			Treatment A : 0.497 Storage period B : 0.385 Interaction B : 0.860		

In fruit weight than dipping in 2, 5 or the control. So, the percent of total loss for these treatments ranged about 17.1-18.0 %. Yet, the control presented 22.0 % after 60 days of cold storage as a mean of two seasons. The reduction attributed due these treatments mainly due to their effect for reducing both loss in fruit weight and decayed fruits than the control. Whereas, $CaCl_2$ at 5 % increase the percent of total loss in fruit weight significantly than the other concentrations or the control. Similarly, Abdel-Wahab (1986) found that dipping Anna apple fruit in 4 % $CaCl_2$ reducing the percentage of weight loss than these dipping in $CaCl_2$ at 2 or 6 %.

4- Effect on fruit firmness :

Data from Table (4) showed that fruit firmness of Anna apple fruit was significantly reduced from harvest till 30 or 60 days under cold storage. The data also reveal that values of fruit firmness was almost higher with $CaCl_2$ treatments than the control. Since, $CaCl_2$ at 5 % presented 8.4 pound/ $inch^2$, but, it was about 7.8 $lb/inch^2$ for the control after 60 days of cold storage. In this respect, Conway *et al.* (1995) reported that treated apple fruits with 4 % $CaCl_2$ increased the total calcium in cell wall than those treated with 2 %. In this respect, Park and Lee (1996) studied the effect of dipping apple fruits in $CaCl_2$ at 1, 2 or 3 % on flesh firmness found that fruit treated with calcium gave a higher fruit firmness compared with the control. Furthermore,

Abo-Samra (2003) mentioned that sprayed Anna apple fruits with calcium chloride as preharvest treatment increased fruit firmness than the control at harvest time or during storage.

Table 4 : Effect of Calcium application on Firmness (Ib/ inch^2)of Anna apple fruits under cold storage.

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage(B)					
	0	30	60	0	30	60
Control	10.7	9.60	7.80	10.9	8.75	7.75
$CaCl_2$ 2%	10.7	9.11	7.90	10.9	9.59	8.81
$CaCl_2$ 3%	10.7	9.64	8.17	10.9	9.43	8.42
$CaCl_2$ 4%	10.7	10.13	8.18	10.9	9.15	8.11
$CaCl_2$ 5%	10.7	9.88	8.28	10.9	9.66	8.54
L.S.D at 5%	Treatment A : 0.139 Storage period B : 0.108 Interaction B : 0.241			Treatment A : 0.202 Storage period B : 0.157 Interaction B : 0.350		

5- Effect on T.S.S., total acidity and T.S.S /acid ratio in fruit juice :

Data from Table (5) showed that T.S.S. increased significantly during storage from harvest till 60 days of cold storage. Furthermore, $CaCl_2$ at 3 % gave a higher T.S.S in fruit juice than the other concentrations and the control. Furthermore, Table (6) presented that total acidity reduced significantly as the storage period advanced. Yet, $CaCl_2$ at 3 % gave a lower total acidity in fruit juice during the two seasons of the study.

Table (7) showed that T.S.S./acid ratio in fruit juice was gradually increased as a storage period advanced . Yet, all calcium applications except $CaCl_2$ at 2 % increased the values of T.S.S./acid ratio than the control during storage and after 60 days of cold storage. Furthermore, $CaCl_2$ at 3 or 5 % presented a higher values than the other treatment used or the control during the two seasons. Similarly, Abdel-Hameed *et al.* (1996) found that dipping Anna apple fruits in calcium chloride from 1-4 % total soluble solids content and total acidity was increased especially at the highest rate of calcium chloride.

Abo-Samra (2003) reveal that a gradual increase in T.S.S /acid ratio as the storage period advanced, but calcium application presented a higher values than the control. Also, Hussein *et al.* (2001) showed an increase of T.S.S/acid ratio of Anna apple fruits during cold storage.

Table 5 : Effect of Calcium application on T.S.S. of Anna apple fruits under cold storage.

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage(B)					
	0	30	60	0	30	60
Control	11.5	12.1	12.5	12.3	13.0	13.3
$CaCl_2$ 2%	11.5	12.4	12.6	12.3	12.5	13.1
$CaCl_2$ 3%	11.5	12.6	13.0	12.3	12.5	13.4
$CaCl_2$ 4%	11.5	12.0	12.3	12.3	12.6	13.7
$CaCl_2$ 5%	11.5	13.1	13.4	12.3	12.8	13.2
L.S.D at 5%	Treatment A : 0.179 Storage period B : 0.139 Interaction B : 0.311			Treatment A : 0.239 Storage period B : 0.185 Interaction B : 0.414		

Table 6 : Effect of Calcium application on total acidity % of Anna apple fruits under cold storage.

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage(B)					
	0	30	60	0	30	60
Control	0.681	0.614	0.518	0.667	0.595	0.491
$CaCl_2$ 2%	0.681	0.583	0.543	0.667	0.649	0.540
$CaCl_2$ 3%	0.681	0.589	0.493	0.667	0.610	0.464
$CaCl_2$ 4%	0.681	0.578	0.470	0.667	0.646	0.536
$CaCl_2$ 5%	0.681	0.600	0.495	0.667	0.586	0.476
L.S.D at 5%	Treatment A : 0.010 Storage period B: 0.007 Interaction B : 0.017			Treatment A : 0.017 Storage period B: 0.013 Interaction B : 0.030		

Table 7 : Effect of Calcium application on SSC/acid ratio of Anna apple fruits under cold storage .

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage(B)					
	0	30	60	0	30	60
Control	16.9	19.7	24.1	18.4	21.80	27.1
$CaCl_2$ 2%	16.9	21.3	23.2	18.4	19.26	24.3
$CaCl_2$ 3%	16.9	21.4	26.3	18.4	20.10	29.7
$CaCl_2$ 4%	16.9	20.7	26.2	18.4	19.50	25.6
$CaCl_2$ 5%	16.9	21.8	27.1	18.4	20.80	27.7
L.S.D at 5%	Treatment A : 0.539 Storage period B : 0.418 Interaction B : 0.935			Treatment A : 0.557 Storage period B : 0.431 Interaction B : 0.964		

6- Effect on total Anthocyanin content :

From Table (8) it is clear that total anthocyanin in berry skin of Anna apple fruit was gradually decreased from harvest till 60 days of cold storage. Furthermore, calcium chloride application gave a higher significant values of anthocyanin than the control. Since, $CaCl_2$ at 3 or 4 % gave a higher values than the other concentration of $CaCl_2$ or the control.

Table 8 : Effect of Calcium application on anthocyanin content of Anna apple fruits under cold storage .

Treatment (A)	Season 2005			Season 2006		
	Days in cold storage(B)					
	0	30	60	0	30	60
Control	1.395	0.940	0.558	1.400	0.910	0.484
$CaCl_2$ 2%	1.395	0.833	0.650	1.400	0.846	0.658
$CaCl_2$ 3%	1.395	0.933	0.641	1.400	1.000	0.707
$CaCl_2$ 4%	1.395	0.981	0.767	1.400	1.035	0.782
$CaCl_2$ 5%	1.395	1.006	0.633	1.400	0.971	0.736
L.S.D at 5%	Treatment A : 0.038 Storage period B : 0.029 Interaction B : 0.066			Treatment A : 0.028 Storage period B : 0.022 Interaction B : 0.042		

Similar results has obtained by El-Eryan (2002) who mentioned that anthocyanin content in Anna apple gradually reduced as storage period advanced. Also, Abo-Samra (2003) indicated that an obvious increase of anthocyanin concentration in fruit skin of Anna apple under all Ca^{2+} treatments compared with the control.

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تأثير معاملة ثمار التفاح الأنا بكلوريد الكالسيوم بعد الحصاد وأثرها على كفاءة الثمار التخزينية

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أجريت هذه الدراسة خلال عامى ٢٠٠٥ ، ٢٠٠٦ لتقييم تأثير معاملة ثمار التفاح الأنا بتركيزات مختلفة من كلوريد الكالسيوم بعد الجمع وأثر ذلك على خواص الثمار والتغيرات التى تحدث خلال التخزين البارد ولقد أوضحت الدراسة أن نقع ثمار التفاح الأنا فى محلول كلوريد الكالسيوم بتركيز ٣ % أدى إلى تقليل الفقد الكلى فى الثمار معنوياً بالمقارنة بنقع الثمار فى تركيز ٢ أو ٤ %.

فى حين أن نقع ثمار التفاح فى كلوريد الكالسيوم بتركيز ٥ % أظهر إرتفاعاً فى الفقد الكلى فى وزن الثمار بالمقارنة بباقي التركيزات المستخدمة وكذا الثمار الغير معاملة.

علاوة على ذلك فإن كل من صلابة الثمار ومحتوى القشرة من صبغة الأنثوسيانين إنخفض تدريجياً من بعد الجمع حتى ٦٠ يوم من التخزين البارد فى حين أن نقع الثمار فى محلول كلوريد الكالسيوم أعطى زيادة فى صلابة الثمار وكذلك زيادة فى محتوى القشرة من صبغة الانثوسيانين محتواهما سواء وقت الجمع أو خلال التخزين البارد كما أن محتوى عصير الثمار من المواد الصلبة الذائبة للحموضة ازداد مع تقدم الثمار أثناء التخزين ولم يكن المعاملة بكلوريد الكالسيوم أثراً واضحاً فى هذا الصدد.