Effect of Calcium chloride and Gibberellic acid on storability of "Succary Abiad" mango fruits under cold storage

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ABSTRACT: This study was carried out in two successive seasons (2007 and 2008) on Succary Abiad cv. mango trees grown in Abou Swear region, Ismailia Governorate, Egypt. The trees were 30-year-old, planted at 7×7 meters apart. Fruits storability was improved by $CaCl_2$ or GA_3 treatments under cold storage. Fruit weight declined starting from the first week of cold storage up to the end of storage period. GA_3 40 ppm dipping treatment showed the lowest fruit weight loss in the two seasons. The fruit pulp percentage gradually decreased as the storage periods elongated. Fruits from $CaCl_2$ 2% dipping showed the highest fruit pulp percentage compared with the control fruits. Fruit firmness was the highest in fruits treated with $CaCl_2$ 2% sprayed at two months after full bloom or dipping after harvesting. Moreover, SSC increased gradually up to the end of storage periods. While, titratable acidity in the fruits showed gradually decreasing up to the end of storage periods as compared with its values at the beginning of storage. The fruit SSC/acid ratios showed gradually increasing in its values higher than at zero time storage. Total sugars in the fruits increased as the storage period elongated to reach its maximum values at the end of storage period.

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Key words: Mango, $CaCl_2$, GA_3, fruit quality, cold storage.

1. Introduction

Mango (***Mangifera indica* L**) is considered the king of fruits in many countries (Purseglove, 1972). In Egypt, mango cultivated area reached 184204 fed. (Ministry of Agriculture, 2007). More than 40% of this areas exists in Ismailia, where the main cultivar planted is "Succary Abiad". Low fruit calcium levels have been associated with reduced postharvest life and physiological disorders (Wills *et al*., 1998). For example, low levels have been correlated with physiological disorders of mangoes (Van Eeden, 1992). Calcium treatment has been shown to decrease respiration, reduce ethylene production and to delay the onset of ripening in mangoes (Yuniarti Suhardi, 1992).

Preharvest sprays of calcium compounds significantly retained more ascorbic acid in mature green fruits and during storage (Rani and Brahmachari, 2003). The soluble solids and firmness were also influenced by the higher $CaCl_2$ concentrations. Reddy and Haripriya (2002) found that the GA_3 (200 ppm) significantly reduced the physiological loss in weight, delayed color development and ripening and had longer shelf life. Besides, the fruits also exhibited better quality because of its favorable effect on slower increase in total soluble solids, sugars and retaining more acidity thereby rendering them acceptable up to a period of 18 days in "Bangalora" and 17 days in "Neelum" cvs. Preharvest sprays of GA_3 significantly retained more ascorbic acid in mature green fruits and during storage (Rani and Brahmachari, 2003). Singh *et al*. (2007) studied the effect of GA_3 (0.5% w/v dipping) the ripening of mango "Dashehari" fruit was investigated at physiological and biochemical level. A decreased in fruit firmness was directly related with ripening. Firmness of untreated mango fruit (control) showed decrease from 181.3 to 112.7 N during the ripening period in this study. GA_3 did not reduce softening compared to their respective controls. The TSS increased gradually during fruit ripening in both treated and control samples. In untreated fruits, there was 1.88-fold increase in TSS during the study period. The difference in TSS between days 0 and 11 was 11 % on control and 8.5 % in GA_3 treated fruit.

The main objective of this study was to investigate the effect of calcium chloride and gibberellic acid on fruit storability during cold storage.

2. Materials and Methods

The present study was conducted throughout two successive seasons of 2007 and 2008 on mango cv. "Succary Abiad" at Abou Swear region, Ismailia Governorate, Egypt. The trees were grown in a sandy soil and irrigated with immerged irrigation system. The trees were 30-year-old and planted at 7 × 7m space.

This work aimed to study the effect of calcium chloride and gibberellic acid on fruit quality of "Succary Abiad" mango during cold storage and marketability. Eight treatments with three replicates were used and arranged in complete randomize design. The treatments were as follows:-

No.	Treatments	Date of
1	Control (water)	One month after
2	$CaCl_2$ 2%	One month after
3	$CaCl_2$ 2%	Two months
4	GA_3 20 ppm	Two months
5	GA_3 40 ppm	Two months
6	$CaCl_2$ 2% dipping	After harvest
7	GA_3 20 ppm	After harvest
8	GA_3 40 ppm	After harvest

From each treatments, 30 fruits (10 fruits/ replicate) were hand harvested and transported to the lab. of Hort. Dept. Fac. Agri. Suez Canal University within 1hours. of harvest, washed by chlorine solution (100 ppm) and air-dried. Fruits were stored to eliminate defects. 90 untreated fruits (from control trees) were divided into three equal groups each of 36 fruits; the first group dipped in 2 % Ca Cl_2 solution for 20 min., the second one dipped in 20 ppm GA_3 solution for 20 min. and the last group dipped in 40 ppm GA_3 solution for 20 min. then the treated fruits were air drayed. Ten sound fruits put in plastic foam dishes, covered with perforated colorless polyethylene bags (1 mm in diameter hole per 16 cm^2 area) and stored in cold air (12 ± 1 ºC) and 80-85 % RH up to 21 days. At the beginning of the experiment (Zero time storage), fruit samples (two fruits) were taken out for measurements the fruit quality parameters up to 21 days storage.

Studying parameters:

Fruit weight loss (%),pulp/fruit ratio (net ratio), fruit firmness (kg/cm^2) by using effegi pentrometer, soluble solids content (SSC %) by hand refractometer, fruit acidity, SSC/Acid ratio and total sugars were determined as described by A.O. A. C. (1995).

Statistical analysis:

Data were subjected to the analysis of variance and a complete block design was used (Steel and Torrie, 1980). Analysis of variance and mean comparison (LSD, at 5%) were done by MSTAT-C program version 7 (1990).

3. Results and Discussions

Effect of Calcium Chloride ($CaCl_2$) and Gibberellic Acid (GA_3) as pre or post-harvest treatments on fruit storability:

1- The effect on fruit weight loss:-

Data tabulated in table 1 indicated that all treatments appeared progressively decline in the fruit weight starting from the first week up to the end of storage periods (21 days). The different treatments varied in its effects on the fruit weight loss. In the first seasons, at the end of storage periods the treatment GA_3 40 ppm dipping showed the lowest fruit weight loss (4.31 %) while the control fruits appeared the highest fruit weight loss (5.65 %). The other treatments gave intermediate values in this regard. In the second season, the treatment GA_3 40 ppm sprayed at two months after full bloom showed the lowest fruit weight loss (4.42 %) while the control fruits gave the highest fruit weight loss (5.32 %). The other treatments showed intermediate values. The fruit weight loss could be attributed mainly to the water loss from fruit tissues and partially to the respiration process through the storage duration.

The composite effects of storage durations or different treatments were significant in the two seasons. In addition, the interaction effects among storage durations and the different treatments were significant in the two seasons.

The obtained results are in agreement with those of Ranjan *et al.* (2005), Waskar and Gaikwad (2005) and Singh *et al.* (2007) who found that $CaCl_2$ and GA_3 declined the weight loss of mango fruits during storage periods.

2- The effect on fruit pulp:-

Data in table 2 show that fruit pulp percentages gradually decreased as the storage periods elongated with significant differences. At the end of storage periods, in the first seasons, the treatment $CaCl_2$ 2% dipping showed the highest fruit pulp percentage (79.60) followed by those of fruits treated with GA_3 20 ppm sprayed at two months after full bloom (77.39). The lowest value appeared within the control fruits (75.30). In the second season, the fruits of $CaCl_2$ 2% dipping still have the superior effect (77.46) but followed by those from trees sprayed with

Table 1: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit weight loss (%) in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	0.00	2.03	4.29	5.65	2.99 a
CaCl2 2% M. A. F. B.	0.00	1.65	3.24	4.76	2.41 e
CaCl2 2% 2 M. A. F. B.	0.00	1.93	3.56	4.86	2.59 d
GA3 20 ppm 2 M. A. F. B.	0.00	2.00	3.75	5.47	2.80 b
GA3 40 ppm 2 M. A. F. B.	0.00	1.96	3.66	4.84	2.62 d
CaCl2 2% Dipping	0.00	1.83	4.21	5.37	2.85 b
GA3 20 ppm Dipping	0.00	2.03	3.90	4.94	2.72 c
GA3 40 ppm Dipping	0.00	2.13	4.20	4.31	2.66 cd
Mean	0.00 D	1.94 C	3.8 B	5.02 A	
LSD 5% (T × SD)	0.147				
	Season 2008				
Control	0.00	1.93	3.59	5.32	2.71 a
CaCl2 2% M. A. F. B.	0.00	2.03	3.44	5.20	2.67 a
CaCl2 2% 2 M. A. F. B.	0.00	1.98	3.07	5.09	2.53 b
GA3 20 ppm 2 M. A. F. B.	0.00	1.90	3.42	4.94	2.57 b
GA3 40 ppm 2 M. A. F. B.	0.00	1.74	3.25	4.42	2.35 e
CaCl2 2% Dipping	0.00	1.71	3.21	4.93	2.46 c
GA3 20 ppm Dipping	0.00	1.87	3.26	4.72	2.46 c
GA3 40 ppm Dipping	0.00	1.95	3.13	4.56	2.41 d
Mean	0.00 D	1.89 C	3.30 B	4.90 A	
LSD 5% (T × SD)	0.099				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT

M. A. F. B. = one month after Full Bloom **2 M. A. F. B. = Two months after Full Bloom**

Table 2: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit pulp (%) in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	80.97	80.82	77.59	75.30	78.67 e
$CaCl_2$ 2% M. A. F. B.	82.64	82.29	78.21	76.04	79.79 d
$CaCl_2$ 2% 2 M. A. F. B.	82.78	82.48	77.67	76.81	79.93 cd
GA_3 20 ppm 2 M. A. F. B.	84.17	82.70	78.83	76.81	80.63 b
GA_3 40 ppm 2 M. A. F. B.	81.91	81.12	79.98	77.39	80.10 cd
$CaCl_2$ 2% Dipping	83.45	83.27	81.37	79.60	81.92 a
GA3 20 ppm Dipping	83.77	83.69	76.38	77.20	80.26 bc
GA3 40 ppm Dipping	82.65	82.44	79.14	75.89	80.03 cd
Mean	82.79 A	82.35 B	78.64 C	76.88 D	
LSD 5% (T × SD)	0.782				
	Season 2008				
Control	74.65	73.80	73.55	72.95	73.74 f
$CaCl_2$ 2% M. A. F. B.	77.81	77.61	76.36	75.17	76.74 b
$CaCl_2$ 2% 2 M. A. F. B.	75.11	74.94	74.34	73.60	74.50 e
GA_3 20 ppm 2 M. A. F. B.	76.32	75.40	74.74	74.27	75.18 d
GA_3 40 ppm 2 M. A. F. B.	78.29	78.22	75.70	74.77	76.75 b
$CaCl_2$ 2% Dipping	79.30	78.72	77.82	77.46	78.33 a
GA_3 20 ppm Dipping	76.95	76.28	74.97	74.87	75.76 c
GA_3 40 ppm Dipping	76.93	75.45	75.44	74.79	75.65 cd
Mean	76.92 A	76.30 B	75.36 C	74.73 D	
LSD 5% (T × SD)	1.146				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT

M. A. F. B. = one month after Full Bloom **2 M. A. F. B. = Two months after Full Bloom**

$CaCl_2$ 2% applied at one month after full bloom (75.17). The control fruits showed the lowest fruit pulp (72.95) as in the first season. The significant decrease in the fruit pulp percentages could be due to the loss in the fruit fresh weight, which occurred mainly in the pulp while the stone was less affected as compared with its pulp.

3- The effect on fruit firmness:-

Table 3 shows the effect of different treatments on the fruit firmness. Data indicate that at zero time of storage, the fruit firmness differed within the various treatments. In the first seasons, the fruits harvested from trees sprayed with GA_3 40 ppm at two months after full bloom appeared the highest values in this regard (5.35) while those treated with GA_3 40 ppm dipping gave the lowest value (4.28). With the elongation of storage periods, fruits harvested from different treatment lost a part of its firmness. The lost in fruit firmness was gradually in the first week of storage and became faster in the second and third week. At the end of storage duration (21 days) the fruits from trees sprayed with $CaCl_2$ 2% at two months after full bloom showed the highest firmness values (0.98) followed by those treated with GA_3 40 ppm dipping (0.95). The control fruits appeared the lowest fruit firmness value (0.78). In the second season at zero time storage, the fruits of $CaCl_2$ 2% dipping and these of GA_3 20 ppm dipping treatments gave the highest values of fruit firmness (5.48 and 5.44, respectively). During storage periods, the fruit firmness was gradually decreased with storage duration elongation. At the end of storage periods (21 days) the fruits from trees sprayed with $CaCl_2$ 2% at one month after full bloom and those of GA_3 40 ppm dipping showed the highest fruit firmness value (1.50) while those of control gave the lowest value in this regard (0.93). The other treatments showed intermediate values. The compositive effects of various treatments as well as those of storage duration were significant in the two seasons. Moreover, the interaction effects of treatments and storage durations were also significant in two seasons.

The positive effect of $CaCl_2$ could be due to that Calcium has long been known to confer rigidity of cell walls, which in turn reflected on increasing the tissue firmness. Moreover, $CaCl_2$ is very effective in preventing pectin solubilization.

The obtained results are in harmony with those of Hojo *et al.* (2009) who found that calcium is known to delay senescence resulting in firmer fruits and that mango fruit firmness was increased with treatment of calcium as compared to the control.

4- The effect on fruit SSC:-

Data in table 4 indicate that SSC increased in the fruits as a result of different treatments at the beginning of storage higher than control fruits. This was evident in the two seasons, except in the fruits of GA_3 40 ppm dipping in the first season and those of either $CaCl_2$ 2% sprayed at two months after full bloom or those of GA_3 20 ppm sprayed at two months after full bloom. Throughout the storage durations, SSC increased gradually up to the end of storage periods. The increments in SSC during storage periods could be a result of the conversion of organic matter in the fruits to soluble solids throughout the enzymatic activities and processes. The composite effects of each treatments or storage durations on the fruit SSC were significant in the two seasons. Moreover, the interaction effects of storage durations and treatments were also significant in the two seasons.

The obtained results confirmed those of Singh *et al.* (2007) and Hojo *et al.* (2009) who found that $CaCl_2$ or GA_3 treatments increased SSC fruits of mango cvs. as storage durations elongated higher than control.

5- The effect on titratable acidity (TA) content:-

Table 5 shows the effect of the different treatments and storage durations on the fruit titratable acidity contents. Data indicate that at the beginning of storage all treatments increased TA contents in the fruits higher than in control fruits. These were evident in the two seasons of study. During the storage durations, TA in the fruits showed gradually decreasing up to the end of storage periods as compared with its values at zero time of storage. This was noticed in the two seasons within all treatments and all storage periods. The observed decreasing in the fruit acidity could be due to that acids partially are a respiratory substrate and its consumption in respiratory increase with the progresses of storage periods and this may be responsible for the observed decreasing in acidity during the last days of storage.

The compositive effects of treatments or those of storage durations were significant in the two seasons. The interaction effects of treatments and storage durations were also significant in the two

Table 3: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit firmness (kg/cm2) in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	4.45	2.34	0.97	0.78	2.13 e
$CaCl_2$ 2% M. A. F. B.	4.74	3.20	1.65	0.85	2.61 d
$CaCl_2$ 2% 2 M. A. F. B.	4.79	3.20	1.83	0.98	2.70 cd
GA_3 20 ppm 2 M. A. F. B.	4.98	3.68	1.25	0.84	2.69 cd
GA_3 40 ppm 2 M. A. F. B.	5.35	3.43	1.30	0.94	2.76 c
$CaCl_2$ 2% Dipping	4.84	4.49	2.80	0.87	3.25 a
GA_3 20 ppm Dipping	4.36	4.33	2.57	0.90	3.04 b
GA_3 40 ppm Dipping	4.28	4.18	1.48	0.95	2.72 c
Mean	4.72 A	3.61 B	1.73 C	0.89 D	
LSD 5% (T × SD)	0.187				
	Season 2008				
Control	5.14	4.55	2.84	0.93	3.37 d
$CaCl_2$ 2% M. A. F. B.	5.22	5.15	2.85	1.50	3.68 b
$CaCl_2$ 2% 2 M. A. F. B.	4.93	4.80	3.33	1.24	3.58 bc
GA_3 20 ppm 2 M. A. F. B.	5.14	5.00	3.33	1.17	3.66 b
GA_3 40 ppm 2 M. A. F. B.	4.84	4.75	2.98	1.33	3.47 cd
$CaCl_2$ 2% Dipping	5.48	4.64	3.05	1.26	3.61 b
GA_3 20 ppm Dipping	5.44	5.39	3.44	1.40	3.92 a
GA_3 40 ppm Dipping	5.24	5.18	3.84	1.50	3.94 a
Mean	5.18 A	4.93 B	3.21 C	1.29 D	
LSD 5% (T × SD)	0.261				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT
M. A. F. B. = one month after Full Bloom 2 M. A. F. B. = Two months after Full Bloom

Table 4: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit SSC (%) in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	12.40	16.57	18.80	19.53	16.83 a
$CaCl_2$ 2% M. A. F. B.	13.40	13.47	16.07	18.27	15.30 bc
$CaCl_2$ 2% 2 M. A. F. B.	13.60	15.40	17.67	19.27	16.48 a
GA_3 20 ppm 2 M. A. F. B.	12.20	13.57	17.13	17.47	15.09 cd
GA_3 40 ppm 2 M. A. F. B.	13.40	13.40	17.50	18.47	15.69 b
$CaCl_2$ 2% Dipping	12.33	16.27	18.47	18.40	16.37 a
GA_3 20 ppm Dipping	12.73	11.77	16.27	17.83	14.65 d
GA_3 40 ppm Dipping	11.80	12.80	17.40	18.13	15.03 cd
Mean	12.73 D	14.15 C	17.41 B	18.42 A	
LSD 5% (T × SD)	1.016				
	Season 2008				
Control	8.00	16.47	17.40	23.13	16.25 a
$CaCl_2$ 2% M. A. F. B.	9.07	10.47	17.73	21.33	14.65 b
$CaCl_2$ 2% 2 M. A. F. B.	7.53	9.33	15.87	17.27	12.50 d
GA_3 20 ppm 2 M. A. F. B.	7.00	10.13	14.87	17.73	12.43 d
GA_3 40 ppm 2 M. A. F. B.	8.40	10.50	12.87	16.33	12.03 d
$CaCl_2$ 2% Dipping	8.07	11.27	15.33	19.20	13.47 c
GA_3 20 ppm Dipping	8.20	11.73	17.20	17.33	13.62 c
GA_3 40 ppm Dipping	8.13	11.20	17.40	21.07	14.45 b
Mean	8.05 D	11.39 C	16.08 B	19.18 A	
LSD 5% (T × SD)	1.147				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT
M. A. F. B. = one month after Full Bloom 2 M. A. F. B. = Two months after Full Bloom

Table 5: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit TA (%) in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	1.67	1.36	1.33	1.23	1.40 f
$CaCl_2$ 2% M. A. F. B.	1.74	1.39	1.24	1.22	1.40 e
$CaCl_2$ 2% 2 M. A. F. B.	1.79	1.72	1.44	1.31	1.57 c
GA_3 20 ppm 2 M. A. F. B.	1.82	1.72	1.47	1.14	1.54 d
GA_3 40 ppm 2 M. A. F. B.	1.89	1.44	1.42	1.26	1.50 e
$CaCl_2$ 2% Dipping	1.98	1.86	1.67	1.31	1.71 a
GA_3 20 ppm Dipping	1.87	1.82	1.44	1.37	1.62 b
GA_3 40 ppm Dipping	1.85	1.56	1.36	1.26	1.51 f
Mean	1.83 A	1.61 B	1.42 C	1.26 C	
LSD 5% (T × SD)	0.051				
	Season 2008				
Control	1.89	1.87	1.43	1.65	1.71 f
$CaCl_2$ 2% M. A. F. B.	2.49	2.43	1.66	1.24	1.96 abc
$CaCl_2$ 2% 2 M. A. F. B.	2.26	2.37	1.64	1.75	2.00 a
GA_3 20 ppm 2 M. A. F. B.	2.15	2.09	1.68	1.58	1.88 de
GA_3 40 ppm 2 M. A. F. B.	2.18	2.21	1.77	1.77	1.98 ab
$CaCl_2$ 2% Dipping	2.10	1.84	1.61	1.72	1.82 e
GA_3 20 ppm Dipping	2.16	2.14	1.73	1.60	1.91 cd
GA_3 40 ppm Dipping	2.28	2.16	1.54	1.72	1.93 bcd
Mean	2.19 A	2.14 B	1.63 C	1.63 C	
LSD 5% (T × SD)	0.130				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT
M. A. F. B. = one month after Full Bloom **2 M. A. F. B. = Two months after Full Bloom**

Table 6: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit SSC/TA ratio in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	7.43	12.18	14.14	15.88	12.41 a
$CaCl_2$ 2% M. A. F. B.	7.70	9.71	12.96	14.97	11.34 b
$CaCl_2$ 2% 2 M. A. F. B.	7.60	8.96	12.27	14.67	10.87 c
GA_3 20 ppm 2 M. A. F. B.	6.70	7.91	11.69	15.32	10.40 e
GA_3 40 ppm 2 M. A. F. B.	7.09	9.33	12.31	14.69	10.85 cd
$CaCl_2$ 2% Dipping	6.24	8.75	11.05	14.01	10.01 e
GA_3 20 ppm Dipping	6.82	6.47	11.30	13.06	9.41 f
GA_3 40 ppm Dipping	6.39	8.21	12.77	14.39	10.44 de
Mean	7.00 D	8.94 C	12.31 B	14.62 A	
LSD 5% (T × SD)	0.870				
	Season 2008				
Control	4.23	8.80	12.22	14.16	9.85 a
$CaCl_2$ 2% M. A. F. B.	3.64	4.32	10.68	17.25	8.97 b
$CaCl_2$ 2% 2 M. A. F. B.	3.33	3.94	9.77	9.89	6.73 fg
GA_3 20 ppm 2 M. A. F. B.	3.25	4.85	8.84	11.26	7.05 ef
GA_3 40 ppm 2 M. A. F. B.	3.86	4.75	7.26	9.23	6.28 g
$CaCl_2$ 2% Dipping	3.85	6.15	9.51	11.17	7.67 cd
GA_3 20 ppm Dipping	3.80	5.49	9.97	10.82	7.52 de
GA_3 40 ppm Dipping	3.57	5.19	11.28	12.25	8.07 c
Mean	3.69 D	5.44 C	9.94 B	12.00 A	
LSD 5% (T × SD)	1.026				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT
M. A. F. B. = one month after Full Bloom **2 M. A. F. B. = Two months after Full Bloom**

seasons of study. The available results in this study are in agreement with those of Santos *et al.* (2004) and Bringas-Taddei *et al.* (2005). All of them mentioned that TA in mango fruits decreased as a result of $CaCl_2$ or GA_3 treatments with the elongation of storage periods.

6- The effect on fruit SSC/ acid ratio:-

Table 6 shows the effect of different treatments and storage durations on the fruits SSC/ acid ratio. Data appear that at the beginning of storage these ratios fluctuated between 6.24 and 7.70 in the first season while these fluctuations were between 3.25 and 4.23 in the second season. Throughout storage durations, the fruits from all treatments showed gradually increasing in its values in this regard. The increasing in these ratios are due to the increasing in fruit SSC (table 4) and decreasing in acid contents in the same fruits (table 5) with these ratios fluctuated between 6.24 and 7.70 in the first season while these fluctuations were between 3.25 and 4.23 in the second season. Throughout storage durations, the fruits from all treatments showed gradually increasing in its values in this regard. The increasing in these ratios are due to the increasing in fruit SSC (table 4) and decreasing in acid contents in the same fruits (table 5) with increasing storage durations. On the other hand, this ratio was the higher in control fruits than in GA_3 or $CaCl_2$ treated fruits during the different storage periods.

The composite effects of treatments or storage durations were significant in the two seasons. In addition, the interaction effects between treatments and storage durations were significant in the two seasons of study.

The obtained results are in agreement with those of Ahmed and Singh (2000) who found that mango fruits treated with GA_3 showed the lowest SSC/acid ratio.

7- The effect on total sugars content:-

Table 7 shows the effect of various treatments on the total sugars content throughout the storage periods. Data revealed that total sugars in the fruits increased as the storage period elongated to reach its maximum values at the end of storage period. This was evident in the two seasons of study within all treatments. The increasing in total sugars through the storage durations could be due to the conversion of some carbohydrate component like starch to sugars by the enzymatic analysis. At the end of the storage periods, the highest values of total sugars content (18.46 %) were observed in the fruits harvested from trees

Table 7: Effect of CaCl2 and GA3 treatments and storage duration on Succary Abiad fruit total sugars (%) in 2007 and 2008 seasons.

Treatments	Storage duration (SD) (days)				
	0	7	14	21	Mean
	Season 2007				
Control	11.47	15.77	17.49	17.79	15.63 a
$CaCl_2$ 2% M. A. F. B.	8.87	12.03	14.59	16.50	13.00 fg
$CaCl_2$ 2% 2 M. A. F. B.	8.78	14.30	16.74	18.46	14.57 bc
GA_3 20 ppm 2 M. A. F. B.	8.76	12.55	15.35	16.79	13.36 ef
GA_3 40 ppm 2 M. A. F. B.	10.45	12.12	16.37	17.33	14.07 cd
$CaCl_2$ 2% Dipping	9.07	15.28	16.86	17.40	14.65 b
GA_3 20 ppm Dipping	9.96	10.49	14.08	16.63	12.79 g
GA_3 40 ppm Dipping	10.43	11.48	15.96	17.07	13.73 de
Mean	9.72 D	13.00 C	15.93 B	17.25 A	
LSD 5% (T × SD)	1.027				
	Season 2008				
Control	6.07	15.48	16.03	21.39	14.75 a
$CaCl_2$ 2% M. A. F. B.	7.82	8.34	16.67	19.51	13.09 b
$CaCl_2$ 2% 2 M. A. F. B.	6.88	8.45	14.50	15.13	11.24 cd
GA_3 20 ppm 2 M. A. F. B.	5.63	8.25	13.88	16.37	11.03 de
GA_3 40 ppm 2 M. A. F. B.	7.61	7.18	11.50	15.44	10.43 e
$CaCl_2$ 2% Dipping	5.23	14.13	14.06	18.28	12.93 b
GA_3 20 ppm Dipping	5.92	10.49	15.55	15.66	11.91 c
GA_3 40 ppm Dipping	5.95	10.27	16.61	19.47	13.07 b
Mean	6.39 D	10.32 C	14.85 B	17.66 A	
LSD 5% (T × SD)	1.385				

Values with the same small letter in each column are not significantly different at 5 % level DMRT
Values with the same capital letter in each row are not significantly different at 5 % level DMRT
M. A. F. B. = one month after Full Bloom 2 M. A. F. B. = Two months after Full Bloom

sprayed with $CaCl_2$ 2% applied at two months after full bloom and those of controls (21.39 %) in the first and second seasons, respectively. The other treatments showed intermediate values in this regard. The composite effects among either treatments or storage durations were significant in the two seasons. Moreover, the interaction effects among treatments and storage durations were significant in the two seasons.

The obtained results confirm those of Kumar and Singh (1993), Singh *et al.* (2000), Silva & Menezes (2001) and Reddy & Haripriya (2002) who reported that $CaCl_2$ and GA_3 treatments significantly increased total sugars during cold storage of mango fruits.

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