Effect of Foliar Application of Calcium and Zinc on Shelf Life and Fruit Quality of Succary Abiad Mango Cultivar

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Abstract: This study was carried out on Succary Abiad mango trees to investigate the effect of spraying with Ca or Ca+ Zn on shelf life and fruit quality. Fruit weight loss was the lowest in the treated fruits than controls throughout storage periods. Fruit firmness was maintained along storage periods in the treated fruits while it significantly decreased in control fruits. The fruit pulp SSC during storage periods was not affected by Ca or Ca+ Zn treatments while acidity, SSC to acidity ratio, ascorbic acid, total sugars, significantly increased during storage periods compared to controls. Fruit decay symptoms were delayed in the treated fruits with Ca or Ca+ Zn while it appeared in untreated fruits after 6days storage. Fruits treated with Ca 1.0%+Zn 0.2% or Ca 2.0%+ Zn 0.2% could be stored for up to 9 days under shelf life. This could give commercial advantage for marketing and for long distance transport over a limited period.

Keywords: Calcium chloride, Zinc sulphate, Shelf life, Mango, Storage, Firmness, SSC, Ascorbic acid, Total sugars, acidity

INTRODUCTION

Succary Abiad mango cultivar is widely grown in Ismailia, Egypt because of its early fruit maturity which marketing price very high. However, Succary Abiad fruit has a very short shelf life and little durability. A number of workers have reported that pre-or postharvest application of calcium extended the shelf life of mango fruits by maintaining firmness, reducing weight loss of fruit and delaying fruit ripening (Mootoo, 1991;Singh *et al.*, 1993; Suntharalingam, 1996;Sanjay *et al.*, 1998 and Chitarra *et al.*, 2001). Silva *et al.*, (2001) indicated that foliar spray of Ca on Tomy Atkins cv. increased SSC and soluble sugars but decreased acidity. Kumar and Kumar (1989) found that fruits sprayed with zinc showed less weight loss, reduced spoilage, higher sugar content and lower acidity than unsprayed fruits. However, Pendias and Pendias, (1998) mentioned that zinc has physiological roles in stimulating the resistance of plants, to bacterial and fungal diseases. Therefore, direct spray of these nutrients onto mango trees is practiced to help the tree to obtain sufficient calcium and zinc to improve fruit quality, extend shelf life and increase the resistance to physiological disorders. The objective of this experiment was to study the effects of foliar application of calcium alone or with zinc sulphate on shelf life and fruit quality.

MATERIALS AND METHODS

This investigation was carried out during three successive seasons (2000 to 2002) on Succary Abiad mango cv. trees (*Mangifera indica L.*) grown in a sandy soil in a private orchard at Abou Sweer, Ismailia, Governorate, Egypt, to study the effect of foliar applications of calcium and zinc on shelf life and fruit quality. Selected trees were 25-year-old, healthy, nearly uniform in growth vigour, planted at 7x7 m apart and received the same cultural practices. The experimental treatments were as follows:

1-Control treatment was sprayed with tap water.
2-Calcium chloride at 1%.
3-Calcium chloride at 2%.
4-Calcium chloride at 1%+ zinc sulphate at 0.2%.
5-Calcium chloride at 2%+ zinc sulphate at 0.2%.
6-Calcium chloride at 1%.
7-Calcium chloride at 2%.
8-Calcium chloride at 1%+ zinc sulphate at 0.2%.
9-Calcium chloride at 2%+ zinc sulphate at 0.2%.

The treatments (2-5) were sprayed once at pea stage (30 days after full bloom), while the treatments (6-9) were sprayed twice; i.e. at pea stage and at marble stage (60 days after full bloom). Triton (0.1%) was added to the spray solution or water as a surfactant. Each treatment consisted of 3 replicates with one tree for each. Fifteen unblemished fruits were handly picked from each treated tree at early mature stage (fruit quite hard and shoulders well rounded) to study the effect of foliar applications of calcium and zinc on fruit quality during shelf life. Fruits were transported to the lab within 30 min. of harvest, washed by chlorine solution (100 ppm) and air dried, then stored under room condition (23±2°C and 60-65 % RH). At the beginning of the experiment (zero time) and after three day intervals of storage, sample of five fruits were taken to determine :

- **Fruit weight loss**: The fruits were labeled at harvest and weighed. At each sampling time, the fruits were re-weighed and the weight loss was calculated by subtracting the sample's fresh weight after storage from its original weight before storage and divided by its weight before storage.
- **Fruit firmness** (N) was measured on two sides of the fruit using Effegi penetrometer (Mc Cormick, Yakima, Washington) with 0.7 cm plunger.
- **Soluble solids content** (SSC%) was measured by hand refractometer.
- **Fruit acidity** was determined as citric acid content (%) and SSC/acid ratio was calculated.
- **Vitamin C** was determined as milligrams of ascorbic acid per 100 g pulp according to A.O.A.C. (1985).
- **Total sugars** were determined according to Stewart (1974). The optical density was measured at 620 nm using a Spectro 22 spectrophotometer (Labomed Inco, USA).

- **Decayed fruits** were separated and expressed as percentage in relation to each sample weight.
- **Statistical analysis:** Data were subjected to the analysis of variance using completely randomized design with a factorial arrangement of storage periods and treatments (Steel and Torrie, 1980). Analyses of variance and mean comparison (LSD at 5%) were done using M-STAT program version 7 (1990).

RESULTS AND DISCUSSION

1- Fruit weight loss:

Data in Table (1) show the effect of the spraying with either Ca or Zn on the fruit storage duration. Results indicated that in the first season fresh weight loss was the highest in the control fruits with significant differences among these fruits and those of all the tested treatments except Ca 1% single application treatment. The more effective treatment in this regard was Ca 1%+ Zn 0.2% spraying at two additions. The second and third seasons seemed similar trends like that of the first one although the fresh weight loss was relatively higher in either control or different treatments. The obtained results are in agreement with those of Singh *et al.*, (1987), Mootoo (1991), Ray *et al.*, (1993), Singh *et al.*, (1993), Yun *et al.*, (1993), Galvis and Hernandez (1994), Suntharalingam (1996), Sanjay *et al.*, (1998), Chitarra *et al.*, (2001) who found that Ca treatments decreased the weight loss of mango fruits and elongated storage period than control. Contrary results were detected by Freire-Junior and Chitarra (1999), Kluge *et al.*, (1999), Silva and Menezes (2000) and Joyce *et al.*, (2001) who reported that Ca treatments did not affect weight loss in the stored mango fruits.

2- Fruit firmness:

Data in Table (2) show the effect of Ca and Zn spraying on fruit firmness. Results indicated that during storage periods, there was significant decrease in the values of this parameter. This was clear in the tested three seasons. Ca spraying at any of the tested concentrations significantly maintained the fruit firmness along the storage periods as compared with control fruits. The Ca addition at 2% was more effective than 1% and two additions were better than one addition. Moreover, Ca+ Zn spraying appeared best firmness maintenance than Ca alone. This was approximately noticed within the different tested treatments throughout the three seasons of study. The interaction effects of storage periods and spraying treatments were significant in the three seasons. The improving effect of Ca addition on fruit firmness could be due to its effect on the skin, texture. Poovaiah *et al.*, (1988) reported that apple calcium treated fruits remained firmer after 3 months of storage as compared to controls. They suggested that the fruits retain the ability response to calcium treatment for prolonged periods after harvest.

3- Pulp soluble solids content (SSC):

Data in Table (3) showed that in the first season, SSC significantly increased as the storage period increased. Spraying the trees with either Ca or Ca+ Zn showed no significant effect in this concern. The storage periods appeared significant increments in the pulp SSC. The interaction effects of storage periods and spraying treatments had no significant effect on the pulp SSC. In the other two seasons the pulp SSC showed similar trends like those of the first season, but there was significant effect for either Ca or Ca+ Zn concentrations and also for the storage periods. Ca at 2% twice additions gave the highest SSC values while Ca at 2%+ Zn at 0.2% two applications in the second season and Ca 1%+ Zn 0.2% once addition in the third season gave the lowest values. The other spraying treatments gained intermediate values. The interaction effect for either Ca or Ca+ Zn spraying and storage periods in the second and the third seasons were significant.

4- The pulp acidity:

Data in Table (4) indicate that acidity in the pulp significantly decreased with the increase of storage period. Moreover, all the treatments decreased the pulp acidity less than controls. This was evident in the three seasons. In the first season, Ca 1%+ Zn 0.2% two additions gained the highest pulp acidity among the different spraying treatments while the treatment of Ca 1% two applications showed the lowest pulp acidity. In the second season, the treatment Ca 2.0%+ Zn 0.2% twice additions gave the highest values of pulp acidity while the treatment Ca 1%+ Zn 0.2% two sprays showed the lowest acidity per cent in the pulp. In the third season, the treatment Ca 2% one addition gave the highest acidity values while the treat Ca 2%+ Zn 0.2% two sprays gained the lowest acidity values. The other treatments showed intermediate values in this regard. The storage periods appeared significant effect on the pulp acidity. The interaction effects of Ca+ Zn spraying and storage periods were significant in the first and third seasons while it were not significant in the second one.

5- The pulp SSC/acidity ratio:

Data in Table (5) show that during the three seasons SSC/acidity ratio significantly increased with elongation the storage period. These increments were a result of the increase of SSC with the increase of storage period in one side and the decrease in acidity in the other side. The storage periods showed significant increase in the SSC/acidity ratios during the three seasons. In the first season the highest values of this parameter were observed with the Ca 1% added two times while the lowest values were shown with Ca 1%+ Zn 0.2% applied at two times. In the second season, the treatment of Ca 2% added at two sprays gave the highest values while Ca 2%+ Zn 0.2% sprayed two times had the lowest values. In the third season, the treatment of Ca 2%+ Zn 0.2% added two times appeared the highest value while the treatment of Ca 2% sprayed one time had the lowest values in this concern. The other treatments gained intermediate values. The interaction effects of Ca or Ca+ Zn spraying and the storage periods were not significant in the three seasons.

6- The pulp ascorbic acid content:

Data in Table (6) indicate that in the first season, the pulp ascorbic acid content significantly decreased with prolong the storage period. Contrary results were

detected in the other two seasons where this parameter increased with increasing the storage periods. As for the effect of the different treatments on the pulp ascorbic acid content, in the first season the treatment of Ca 1% sprayed one time had the highest value while the treatment of Ca 2% added one time gave the lowest value. In the second season all treatments had no significant effects except the treatment of Ca 1%+ Zn 0.2% added two sprays which showed significant decrease than either control or the other treatments. In the third season, the highest value appeared with the treatment of Ca 2%+ Zn 0.2% added one time while the lowest value was observed with the treatment of Ca 1%+ Zn 0.2% added one spray. The other treatments gained intermediate values. The interaction effects of Ca or Ca+ Zn spraying and storage periods were significant in the first and third seasons while in the second one these effects were not significant.

7- The pulp total sugars content:

Data in Table (7) show that the total sugars content in the fruit pulp significantly increased as the storage period increased. This was evident in the three seasons within all the different Ca or Ca+ Zn spraying treatments. These increments could be due to the conversion of the some organic components in the pulp to sugars by the specific enzymes as the fruits advanced in their ripening stages during the storage periods. Concerning the effect of Ca or Ca+ Zn spraying on pulp total sugars content, in the first season data showed that the treatment of Ca 2% added one spray gave the highest value of total sugars content while the treatment of Ca 1% added one spray had the lowest value. In the second season, the treatment of Ca 1% added one time showed the highest value while the treatment of Ca 1% added two sprays had the lowest value. In the third season, the treatments of Ca 1% added one spray and the treatment of Ca 2%+ Zn 0.2% sprayed one time gave the highest values while the treatment of Ca 1%+ Zn 0.2% added two sprays had the lowest value. The interaction effects of Ca or Ca+ Zn spraying and storage periods were significant in the first and the second seasons while in the third one these effects were not significant.

8- Fruit decay:

Data in Table (8) show that in the three seasons of this study there was no decay symptoms could be observed on the fruits after three days of storage. This was evident in the fruits from treated trees or controls. After storage for six days the decay symptoms became to appear. The highest values for this parameter were obtained from control fruits while the lowest values were gained from fruits of trees sprayed twice with Ca 1.0%+ Zn 0.2% or Ca 2.0%+ Zn 0.2%. The other treatments gained intermediate values in this regard. This was observed in the three tested seasons. After storage for nine days, the decay percentage increased but with different values where the control fruits appeared approximately two folds of decay percentages as comparing with those storage for six days. On the other hand, the fruits from trees sprayed with Ca 1.0%+ Zn 0.2% or Ca 2.0%+ Zn 0.2% still had the lowest decay percentage values. Statistical analysis for the mean values of decay percentages among different treatments displayed highly significant effects for the calcium or calcium+ zinc spraying especially at two sprays. This was noticed in the three seasons of this study. Hepler and Wayne (1985); Poovaiah (1985) and Poovaiah *et al.*, (1988) reported that many physiological disorders of stored fruits are related to the calcium content in the tissues of these fruits. Singh *et al.*, (1987) sprayed Amrapali mango trees with 0.5-2.0% calcium chloride before harvesting and found that all treatments extended edible quality for more than 10 days while control fruits remained acceptable for only 4 days. Ray *et al.*, (1993) showed that spraying Bombay cv. mango trees with calcium chloride increased the storage life and maintained the fruit quality. They added that spraying twice was more effective than a single spray. Similar results were found by Singh *et al.*, (1993) on Dashehari mango cv. fruits and eventually, Galvis and Hernandez (1994) on Tommy Atkins cv. mango fruits.

Concerning the effect of zinc spraying on the previously mentioned regarding, fruit quality during and after storage, Kumar and Kumar (1989) sprayed Dashehari cv. mango trees with 1.0%. Zinc sulphate single or twice sprays and found that these treatments reduced fruit spoilage and two zinc spray applications were most effective. Pendias and Pendias (1998) mentioned that zinc is believed to stimulate the resistance to bacterial and fungal diseases. The good maintaining effects of either calcium chloride or zinc sulphate spraying on fruit quality throughout and after storage in this research could be due at least partially to the effect of these two mineral on strengthing the cell walls and the middle lamella of fruit tissues. The obtained results belong the effects of Ca or Ca+ Zn spraying on the fruit quality during storage duration which previously mentioned (1-8) are in agreement with those of Poovaiah *et al.*, (1988) who mentioned that calcium treatments maintained fruit firmer as compared to control. They added that this suggested that the fruits retain the ability to respond to calcium treatment for prolonged periods after harvest. Corrales and Lakshminarayana (1991) who reported that calcium treatment delayed softening in Tommy Atkins mango fruits but had no effect on the soluble solids content; Ray *et al.*, (1993) who found that spraying with Ca maintained the fruit quality of mango cv. Bombay, they added that spraying twice was more effective than single spray; Singh *et al.*, (1993) who investigated that spraying Dashaheri mango trees with Ca delayed ripening and improved fruit quality during storage in ambient conditions (35°C and 65% RH). Moreover, Ca treated fruits showed less weight loss than control; Sanjay *et al.*, (1998) who reported that shelf life of mango cv. Amrapali fruits was enhanced as judged from the pattern of physiological loss in weight, T.S.S., acidity, total sugars and ascorbic acid contents; Evangelista *et al.*, (2000) mentioned that preharvest spraying with $CaCl_2$ on Tomy Atkins mango trees gave firmer fruits, besides lower activity of pectin methylestrase in the fruits of the treated trees than control; Silva *et al.*, (2001) indicated that preharvest

Table (1): Effect of foliar applications of calcium and zinc on fruit weight loss (%) of Succary Abiad mango cv. fruits during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Fruit weight loss (%)											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		0.00	17.08	22.94	13.34 [a]	0.00	23.14	27.56	16.90 [a]	0.00	23.11	23.86	15.66 [a]
Ca 1%	Once	0.00	15.29	17.68	10.99 [ab]	0.00	22.78	27.15	15.54 [ab]	0.00	20.51	19.64	13.38 [ab]
Ca 2%	Once	0.00	12.32	17.29	9.87 [b]	0.00	21.28	26.24	15.84 [ab]	0.00	19.75	18.18	12.64 [bc]
Ca 1% + Zn 0.2%	Once	0.00	13.93	16.82	10.25 [b]	0.00	21.71	23.02	14.91 [abc]	0.00	17.91	16.94	11.62 [bcd]
Ca 2% + Zn 0.2%	Once	0.00	13.24	14.62	9.29 [b]	0.00	17.26	19.91	12.39 [cd]	0.00	15.46	16.69	10.72 [cde]
Ca 1%	Twice	0.00	11.90	14.96	9.50 [b]	0.00	18.19	21.33	13.18 [bc]	0.00	13.59	15.85	9.81 [de]
Ca 2%	Twice	0.00	11.07	13.92	8.11 [bc]	0.00	12.98	16.94	9.97 [de]	0.00	13.77	15.15	9.64 [de]
Ca 1% + Zn 0.2%	Twice	0.00	10.28	8.42	6.24 [c]	0.00	7.19	8.53	5.24 [f]	0.00	9.24	7.31	5.52 [f]
Ca 2% + Zn 0.2%	Twice	0.00	11.74	13.14	8.29 [bc]	0.00	10.05	15.29	8.49 [e]	0.00	11.35	13.84	8.40 [e]
Mean		0.00 C	12.91 B	15.72 A		0.00 C	16.82 B	20.67 A		0.00 C	14.40B	16.38A	
L.S.D. 5% TxSD*			3.05				4.12				3.31		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

Table (2): Effect of foliar applications of calcium and zinc on firmness (N) of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Firmness (N)											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		15.43	7.94	4.41	9.26 [d]	18.31	12.46	6.44	12.40 [f]	18.74	10.62	4.96	11.44 [d]
Ca 1%	Once	15.69	8.14	5.27	9.70 [d]	19.20	13.87	8.16	13.74 [e]	22.02	12.70	5.98	13.58 [cd]
Ca 2%	Once	16.51	8.73	5.52	10.25 [cd]	20.07	15.36	8.67	14.70 [de]	25.16	15.08	6.58	15.60 [bc]
Ca 1% + Zn 0.2%	Once	16.54	8.76	5.62	10.31 [cd]	21.02	15.99	9.06	15.35 [cd]	27.02	14.20	8.10	16.44 [b]
Ca 2% + Zn 0.2%	Once	18.99	9.38	6.01	11.46 [bcd]	21.42	17.08	9.42	15.97 [bcd]	25.76	14.52	7.10	15.80 [bc]
Ca 1%	Twice	20.40	10.59	6.30	12.43 [abc]	22.07	17.33	9.36	16.26 [bc]	26.86	13.50	7.94	16.10 [b]
Ca 2%	Twice	20.40	11.32	6.38	12.70 [ab]	23.88	16.86	9.53	16.76 [ab]	27.18	14.66	7.60	16.48 [b]
Ca 1% + Zn 0.2%	Twice	22.20	10.77	6.81	13.26 [ab]	24.43	18.80	10.13	17.79 [a]	29.22	15.08	8.26	17.52 [ab]
Ca 2% + Zn 0.2%	Twice	21.92	12.85	6.65	13.81 [a]	25.58	19.11	9.45	18.05 [a]	33.14	15.00	8.78	18.98 [a]
Mean		18.68 A	9.83 B	5.89 C		21.78 A	16.32 B	8.91 C		26.12 A	13.94 B	7.26 C	
L.S.D. 5% TxSD*			1.77				2.14				3.76		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

spraying with Ca on Tommy Atkins mango trees increased SSC and soluble sugars but decreased total titratable acids.

On contrary to the finding results in this research, Kluge *et al.*, (1999) and Sampaio *et al.*, (1999) demonstrated that neither weight loss, total soluble solids, total titratable acidity nor pulp firmness of Tommy Atkins mango fruits were affected during storage at 25°C and 60-70% RH as a response of Ca treatments before harvest.

Table (3): Effect of foliar applications of calcium and zinc on soluble solids content (SSC) (%) of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Soluble solids content (SSC) (%)											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		14.33	16.67	17.33	15.78 [a]	13.13	17.33	14.00	14.82 [ab]	12.07	15.47	12.73	13.42 [bc]
Ca 1%	Once	14.00	16.33	15.33	15.22 [a]	13.40	17.33	14.00	14.91 [ab]	12.87	14.47	13.40	13.58 [abc]
Ca 2%	Once	14.00	15.67	17.33	15.67 [a]	13.73	16.00	13.33	14.36 [bc]	12.13	14.93	13.07	13.38 [bc]
Ca 1% + Zn.2%	Once	14.67	15.33	17.67	15.89 [a]	13.20	15.33	11.33	13.29 [c]	12.20	12.13	13.73	12.69 [c]
Ca 2% + Zn .2%	Once	13.00	15.67	15.67	14.78 [a]	12.33	16.33	12.67	13.78 [bc]	12.20	14.40	13.67	13.42 [bc]
Ca 1%	Twice	13.67	17.00	17.67	16.11 [a]	14.07	14.33	14.00	14.13 [bc]	12.93	14.33	14.20	13.82 [ab]
Ca 2%	Twice	13.67	15.33	16.67	15.22 [a]	14.40	16.33	17.00	15.91 [a]	14.60	14.47	14.07	14.38 [a]
Ca 1% + Zn .2%	Twice	13.33	16.33	17.00	15.56 [a]	11.93	14.67	12.67	13.09 [cd]	13.47	14.87	13.87	14.07 [ab]
Ca 2% + Zn .2%	Twice	14.00	16.67	16.00	15.56 [a]	13.93	11.07	10.67	11.89 [d]	11.27	14.40	14.07	13.24 [bc]
Mean		13.85 C	16.00 B	16.74 A		13.45 B	15.41 A	13.29 B		12.64 C	14.38 A	13.64 B	
L.S.D. 5% TxSD*			N.S.				2.29				1.49		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

Table (4): Effect of foliar applications of calcium and zinc on acidity (%) of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Acidity (%)											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		1.01	0.90	0.40	0.77 [a]	0.73	0.46	0.36	0.51 [a]	0.86	0.53	0.42	0.60 [a]
Ca 1%	Once	0.80	0.83	0.25	0.63 [ab]	0.44	0.33	0.29	0.35 [ab]	0.59	0.48	0.35	0.47 [bc]
Ca 2%	Once	0.76	0.68	0.23	0.56 [bc]	0.41	0.36	0.32	0.36 [ab]	0.72	0.47	0.34	0.51 [a]
Ca 1% + Zn 0.2%	Once	0.96	0.76	0.27	0.66 [ab]	0.46	0.29	0.33	0.36 [ab]	0.62	0.41	0.33	0.45 [bc]
Ca 2% + Zn 0.2%	Once	0.89	0.53	0.25	0.56 [bc]	0.37	0.36	0.32	0.35 [ab]	0.57	0.46	0.32	0.45 [bc]
Ca 1%	Twice	0.67	0.44	0.29	0.47 [c]	0.55	0.29	0.32	0.39 [ab]	0.53	0.51	0.30	0.50 [ab]
Ca 2%	Twice	0.87	0.60	0.29	0.59 [bc]	0.43	0.29	0.29	0.34 [ab]	0.51	0.45	0.26	0.40 [cd]
Ca 1% + Zn 0.2%	Twice	0.99	0.72	0.32	0.68 [ab]	0.34	0.26	0.29	0.29 [b]	0.56	0.44	0.28	0.43 [bcd]
Ca 2% + Zn 0.2%	Twice	0.77	0.55	0.32	0.55 [bc]	0.42	0.33	0.28	0.41 [ab]	0.43	0.42	0.26	0.37 [d]
Mean		0.83 A	0.64 B	0.28 C		0.42 A	0.31 B	0.29 B		0.58 A	0.44 B	0.30 C	
L.S.D. 5% TxSD*			0.16				N.S.				0.096		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

Table (5): Effect of foliar applications of calcium and zinc on SSC/acidity ratio of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	SSC/acidity ratio											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		14.19	18.52	43.32	25.34 [ab]	17.98	37.67	38.89	31.51 [a]	14.03	29.19	30.31	24.51 [ab]
Ca 1%	Once	17.58	19.83	65.33	34.25 [ab]	30.79	53.19	48.22	44.07 [ab]	22.47	30.13	38.99	35.53 [d]
Ca 2%	Once	18.43	23.33	69.82	37.19 [ab]	33.24	44.73	42.53	40.17 [bc]	16.82	32.04	38.21	29.02 [d]
Ca 1% + Zn 0.2%	Once	15.42	20.14	56.96	30.84 [ab]	29.31	54.03	34.62	39.32 [bc]	19.84	29.80	43.30	30.98 [cd]
Ca 2% + Zn 0.2%	Once	14.81	35.14	63.89	37.95 [ab]	34.01	44.56	39.69	39.42 [bc]	21.49	31.24	43.29	32.01 [bcd]
Ca 1%	Twice	21.51	38.67	58.37	39.52 [a]	28.49	50.34	44.40	41.08 [bc]	24.29	28.57	46.91	33.26 [abcd]
Ca 2%	Twice	16.14	25.81	54.49	32.15 [ab]	33.26	56.25	58.62	49.38 [a]	23.78	36.35	49.66	36.60 [ab]
Ca 1% + Zn 0.2%	Twice	13.34	22.89	51.04	29.09 [b]	36.33	56.50	44.37	45.73 [ab]	24.19	34.07	49.37	35.87 [abc]
Ca 2% + Zn 0.2%	Twice	18.41	30.29	52.08	33.59 [ab]	33.64	34.70	38.62	35.65 [c]	26.20	33.76	53.74	37.90 [a]
Mean		17.14 C	26.82 B	59.29 A		32.88 C	50.19 A	45.33 B		22.31 C	33.05 B	45.66 A	
L.S.D. 5% TxSD*			N.S.				N.S.				N.S.		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

Table (6): Effect of foliar applications of calcium and zinc on ascorbic acid (mg/100 g) of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Ascorbic acid (mg/100 g)											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		28.53	29.33	20.00	25.96 [ab]	20.27	22.93	29.60	24.27 [a]	26.67	28.53	30.67	28.62 [abc]
Ca 1%	Once	33.07	26.67	22.678	27.47 [a]	20.53	21.07	24.53	22.04 [a]	18.13	29.87	30.40	26.13 [de]
Ca 2%	Once	24.53	23.73	20.80	23.02 [b]	21.60	23.47	27.20	24.09 [a]	20.00	29.87	32.00	27.29 [bcd]
Ca 1% + Zn 0.2%	Once	27.73	24.80	20.27	24.27 [ab]	21.07	20.80	24.53	22.13 [a]	20.00	27.47	27.73	25.07 [e]
Ca 2% + Zn 0.2%	Once	23.20	25.33	22.13	23.56 [b]	21.80	26.67	26.40	24.95 [a]	26.67	30.67	30.67	29.33 [a]
Ca 1%	Twice	31.20	25.33	21.60	26.04 [ab]	22.13	22.93	27.73	24.27 [a]	22.40	32.27	28.27	27.64 [abcd]
Ca 2%	Twice	30.67	26.67	19.47	25.60 [ab]	22.00	23.60	25.60	23.73 [a]	24.00	32.00	30.93	28.98 [ab]
Ca 1% + Zn 0.2%	Twice	28.27	24.53	19.47	24.09 [b]	10.67	16.53	25.07	17.42 [b]	22.67	28.53	29.33	26.84 [cde]
Ca 2% + Zn 0.2%	Twice	24.00	25.60	25.87	25.16 [ab]	21.23	21.07	28.53	23.61 [a]	18.40	28.80	32.00	26.40 [de]
Mean		27.91 A	25.78 B	21.36 C		19.14 C	22.11 B	26.58 A		22.10 B	29.78 A	30.22 A	
L.S.D. 5% TxSD*			5.08				N.S.				3.01		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

Table (7): Effect of foliar applications of calcium and zinc on total sugars (%) of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Total sugars (%)											
		2000				2001				2002			
		Storage duration (days)			Mean	Storage duration (days)			Mean	Storage duration (days)			Mean
		0[z]	3	6		0[z]	3	6		0[z]	3	6	
Control		13.20	20.10	18.70	17.30 ^{bcd}	7.30	12.20	12.60	10.70 ^{ab}	11.80	11.00	12.40	11.70 ^{a}
Ca 1%	Once	9.10	17.70	21.60	16.20 ^{d}	8.60	11.90	12.50	10.90 ^{a}	11.60	10.60	10.40	10.90 ^{ab}
Ca 2%	Once	11.80	20.20	34.20	22.10 ^{a}	8.70	10.50	10.60	9.90 ^{bc}	10.60	10.60	10.40	10.50 ^{ab}
Ca 1% + Zn 0.2%	Once	10.80	20.20	27.30	19.40 ^{b}	7.80	8.00	12.90	9.60 ^{cd}	10.40	10.30	10.40	10.40 ^{b}
Ca 2% + Zn 0.2%	Once	9.50	20.40	25.90	18.60 ^{bcd}	8.90	9.40	13.70	10.60 ^{ab}	10.40	11.10	11.20	10.90 ^{ab}
Ca 1%	Twice	9.90	19.50	24.10	17.80 ^{bcd}	7.90	7.80	10.70	8.80 ^{d}	11.50	10.10	10.90	10.80 ^{ab}
Ca 2%	Twice	8.20	17.40	23.50	16.40 ^{cd}	8.50	7.80	11.90	9.40 ^{cd}	9.40	10.70	10.90	10.40 ^{b}
Ca 1% + Zn 0.2%	Twice	12.10	20.60	23.90	18.80 ^{bc}	9.50	7.50	12.90	9.90 ^{bc}	9.10	9.20	11.10	9.80 ^{b}
Ca 2% + Zn 0.2%	Twice	10.80	18.60	22.20	17.20 ^{bcd}	9.00	8.10	11.40	9.50 ^{cd}	10.50	9.20	11.80	10.50 ^{b}
Mean		10.60 C	19.40 B	24.60 A		8.50 C	9.20 B	12.10 A		10.60 AB	10.30 B	11.00 A	
L.S.D. 5% TxSD*			3.92				1.48				N.S.		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

Table (8): Effect of foliar applications of calcium and zinc on decay (%) of Succary Abiad mango fruit during shelf life in 2000, 2001 and 2002 seasons.

Treatments (T)	No. of applications	Decay (%)													
		2000					2001					2002				
		Storage duration (days)				Mean	Storage duration (days)				Mean	Storage duration (days)				Mean
		0[z]	3	6	9		0[z]	3	6	9		0[z]	3	6	9	
Control		0.0	0.0	19.9	54.1	18.5 ^{a}	0.0	0.0	20.1	46.3	16.6 ^{a}	0.0	0.0	24.0	45.5	17.4 ^{a}
Ca 1%	Once	0.0	0.0	18.3	33.3	12.9 ^{b}	0.0	0.0	20.1	40.1	15.1 ^{a}	0.0	0.0	19.6	35.6	13.8 ^{b}
Ca 2%	Once	0.0	0.0	16.3	25.0	10.3 ^{bc}	0.0	0.0	18.5	22.3	10.2 ^{b}	0.0	0.0	17.9	25.8	10.9 ^{bc}
Ca 1% + Zn 0.2%	Once	0.0	0.0	17.1	20.3	9.4 ^{cd}	0.0	0.0	13.1	21.7	8.7 ^{bc}	0.0	0.0	15.3	23.4	9.7 ^{cd}
Ca 2% + Zn 0.2%	Once	0.0	0.0	11.3	16.6	7.0 ^{de}	0.0	0.0	12.6	18.1	7.7 ^{bc}	0.0	0.0	13.4	15.3	7.2 ^{de}
Ca 1%	Twice	0.0	0.0	10.1	18.1	7.1 ^{cde}	0.0	0.0	8.7	15.2	6.0 ^{cd}	0.0	0.0	12.1	10.1	5.6 ^{ef}
Ca 2%	Twice	0.0	0.0	8.1	13.1	5.3 ^{ef}	0.0	0.0	5.2	10.1	3.8 ^{de}	0.0	0.0	8.0	5.4	3.4 ^{fg}
Ca 1% + Zn 0.2%	Twice	0.0	0.0	0.0	11.6	2.9 ^{f}	0.0	0.0	2.,1	11.2	3.3 ^{de}	0.0	0.0	3.0	4.0	1.8 ^{g}
Ca 2% + Zn 0.2%	Twice	0.0	0.0	0.0	9.3	2.3 ^{f}	0.0	0.0	0.0	7.2	1.8 ^{e}	0.0	0.0	2.0	3.7	1.4 ^{g}
Mean		0.0 C	0.0 C	11.2 B	22.4 A		0.0 C	0.0 C	11.2 B	21.9 A		0.0 C	0.0 C	12.8 B	18.8 A	
L.S.D. 5% TxSD*				3.8					2.9					2.4		

Values with the same small letter in each column or capital letter in each row are not significantly different at 5% level, z: Initial values at harvest prior to storage.
* SD= Storage duration

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تأثير الرش بالكالسيوم والزنك علي جودة ثمار المانجو صنف ا لسكري الأبيض أثناء التخزين في جو الغرفة العادي

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أجريت هذه الدراسة خلال ثلاث سنوات متتابعة (٢٠٠٠-٢٠٠٢) على أشجار مانجو صنف سكرى أبيض نامية فى تربة رملية فى بستان خاص فى منطقة أبو صوير – محافظة الإسماعيلية- الأشجار التى تم اختيارها كانت فى عمر ٢٥ عاما فى حالة جيدة ومتماثلة تقريبا فى حجمها ومنزرعة على مسافة ٧×٧ متر وتعامل المعاملة البستانية العادية.

تهدف هذه الدراسة إلى معرفة تأثير رش هذه الأشجار بمحلول كلوريد الكالسيوم بتركيزي ١، ٢% منفردا أو مضافا إليه كبريتات الزنك بتركيز ٠,٢% على جودة الثمار أثناء التخزين في ا لجو العادي. وقد أظهرت النتائج أن رش الثمار فى المراحل الأولى من حياتها على الأشجار بمحلول كلوريد الكالسيوم منفردا أو مضافا إليه محلول كبريتات الزنك أدى إلى خفض الفاقد فى وزن الثمرة مما زاد من فترة صلاحية الثمرة أثناء التخزين في حين قلت صلابة الثمار مع زيادة فترة التخزين إلا أن الثمار المعاملة بالمعاملات المختلفة أظهرت درجة من الصلابة أعلى منها فى ثمار المقارنة فى كل فترة من فترات التخزين وقد لوحظ أيضا أ ن المعاملات التى احتوت على عنصر الزنك مع الكالسيوم كانت أكثر تأثيرا فى الحفاظ على صلابة الثمار من معاملات الكالسيوم منفردا. لم يتأثر محتوى لب الثمرة من المواد الصلبة الذائبة بأي من المعاملات المستخدمة إلا أنه زاد زيادة معنوية مع إطالة فترة التخزين. وقد أظهرت دراسة أعراض تلف الثمار عدم ظهور أى من أعراض التلف على الثمار بعد اليوم الثالث من التخزين فى جو الغرفة العادي- بعد اليوم السادس من التخزين ظهرت أعراض التلف بدرجات متفاوتة بين المعاملات حيث كانت ما بين صفر%، ٣% فى ثمار معاملات الرش بكلوريد الكالسيوم ١%+ كبريتات الزنك ٠,٢% مرتان وتلك التى تم رشها بكلوريد الكالسيوم ٢%+ كبريتات الزنك ٠,٢% مرتان أيضا بينما وصلت نسبة التلف إلى ما بين ٢٠%، ٢٤% في ثمار أشجار المقارنة بينما جاءت قيم نسبة التلف فى ثمار باقى المعاملات فيما بين هذه القيم- بعد مرور ٩ أيام على تخزين الثمار- إرتفعت نسبة الثمار التالفة حيث وصلت إلى ما بين ٧,٢% ، ١١,٦% فى المعاملتين السابق الإشارة إليهما بينما سجلت ثمار أشجار المقارنة نسب تلف تراوحت بين ٤٥,٥% ، ٥٤,١% وأظهرت باقى المعاملات فيما بين ذلك- أيضا لوحظ أن نسبة التلف تقل مع زيادة كلوريد الكالسيوم المضاف أما عن طريق زيادة تركيزه فى المحلول أو زيادة عدد مرات الرش وذلك خلال المواسم الثلاثة. كما أظهر التحليل الإحصائي لمتوسط قيم التلف لكل معاملة بعد اليوم التاسع من التخزين تأثيرا معنويا عاليا للرش بكلوريد الكالسيوم منفردا أو مضافا إليه كبريتات الزنك خصوصا عند الرش مرتان.