Journal of Horticultural Science & Ornamental Plants 4 (2): 227-234, 2012
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2012.4.2.251

Effect of Some Preharvest Treatments on Quality of Canino Apricot Fruits Under Cold Storage Conditions

Gamal A. Abdrabboh

Department of Horticulture, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt

Abstract: This study was carried out during the two successive seasons of 2010 and 2011 to study the effect of some pre-harvest treatments using calcium chloride (1.5 %), calcium EDTA (1.5 %), calcium nitrate (2%) and zinc sulphate (0.4%) on some fruit quality of Canino apricot fruits under cold storage conditions. All treatments were done one month before maturity stage. The results showed that fruit weight loss (%), decay (%), T.S.S. (%), T.S.S./acid ratio, total sugars of fruits were increased with prolonging the period of cold storage, while fruit firmness as well as total acidity were decreased by prolonging it. Calcium nitrate at 2% was the best treatment for improving fruit quality under cold storage conditions comparing with other treatments.

Key wards: Canino apricot * Pre-harvest * Calcium nitrate * Fruit quality * Cold storage

INTRODUCTION

Apricot is one of the most important and popular stone fruits grown in Egypt. The cultivated area was in year 2010 (6241 ha) equal 14859 feddan [1]. Some of this area is cultivated with Canino cultivar. Cultivation of Canino apricot is faced by some constraints. The most important one is the very short life of its storage (3-5 days) at ambient conditions which might be attributed to its high respiration rate under natural ambient conditions [2, 3]. There is an inverse relation between fruit tissue calcium level and the rate of respiration. Thus calcium sprays during fruit development decreased the respiration rate at harvest stage, senescence and fruit softening [4]. Calcium deficiency has been associated with post-harvest fruit quality disorders [5]. Calcium contributes in improving the rigidity of cell walls and retard tissue softening and delay ripening [6]. Exogenously applied of calcium stabilizes the cell wall protection against the degradation enzymes [7]. The role of calcium as well as zinc in stored grape has been studied [8]. The efficiency of exogenously applied of calcium on apple varies according to calcium source [9], also to calcium concentration [10] as well as time of application on apple [9]. Therefore, the main goal of this work is to study the effect of some pre-harvest foliar sprays with different calcium sources and zinc sulphate on physical and chemical characteristics of Canino apricot fruits under cold storage conditions.

MATERIALS AND METHODS

This study was carried out during two successive seasons of 2010 and 2011 on twelve years old Canino apricot trees grafted on seedling rootstock grown in a private orchard located at Orabi area beside EL- Obour City, Qualubia Governorate, Egypt. Forty five Canino apricot trees nearly similar in vigor were chosen. The trees were cultivated at 4×6 m apart grown in sandy soil, irrigated through drip irrigation system and received the same cultural practices in the farm. Four treatments beside the control where investigated. Each treatment contained 3 replicates each had 3 trees. Randomized complete block design was followed in this investigation. The trees were received the foliar sprays one month before the commencement of maturity stage [11] with calcium chloride ($CaCl_2$)1.5%, calcium EDTA, 1.5% and calcium nitrate Ca $(NO_3)_2$ 2% and 0.4% zinc sulphate ($ZnSO_4$). Fruits from each tree were harvested and transferred to the laboratory. The broken and/or infected fruits were discarded. Sample of 10 fruits/tree was taken at harvesting date to determine the fruit quality

Corresponding Author: Gamal A. Abdrabboh, Department of Horticulture, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

characteristics. Weight loss (%) and decay (%) were measured [12]. Fruit firmness (lb/inch²) was measured using pressure tester (digital force-Gouge Model IGV-O.SA to FGV-100A.Shimpo instruments). TSS (%) was measured by a hand refractometer. Total sugars (mg/g F.W) were determined [13]. Total acidity (%) was measured as malic acid [14]. Therefore the fruits were transferred to the refrigerator to be stored at 0°C and 90-95% relative humidity for thirty days to study the effect of treatments on fruit quality under cold storage. The fruits were taken periodically each five days out of refrigerator to determine the fruit quality characteristics under cold storage conditions.

Statistical Analysis: The significance of differences was examined by applying analysis of variance (GLM- ANOVA) procedures and means were separated by least significant differences test (LSD) at $P<0.05$ [15].

RESULTS AND DISCUSSION

Effect of Pre-harvest Treatments on Canino Fruit Physical Characteristics,

Weight Loss %: Data presented in Table 1 cleared that the minimal fruit weight loss percentage was obtained by $Ca(NO_3)_2$ treatment (2%) sprayed one month before harvesting in both seasons, while the maximal weight loss (%) was recorded by control as well as $ZnSO_4$ (0.4%) treatments in both seasons. Similar results on grape were obtained as fruits which pre-harvest spray 20 days before harvest with 1% calcium nitrate and 0.6 % calcium chloride showed the least weight loss % [16]. Regarding the effect of cold storage period, data in Table 1 cleared that fruit weight loss (%) gradually increased as storage period advanced since five days storage period under cold storage possessed the lowest values in both seasons. The minimal rate of weight loss% of grape under cold storage conditions was gained after pre-harvest foliar spray with Ca $(NO_3)_2$ at 2% [17]. Weight loss % was increased gradually with prolonged storage period [18]. As for the effect of the interaction between storage period and pre-harvest treatments, data in Table 1 cleared that the lowest loss in fruit weight (%) was gained by the interaction between remaining five days in cold storage and receiving Ca $(NO_3)_2$ in both seasons, while, the maximal fruit loss rates were recorded by the interaction between thirty days and control followed by $ZnSO_4$ (0.4%). $CaCl_2$ (2%) treated guava fruits showed lowest weight at seven days of cold storage period while the maximal was recorded by the interaction between 28 days and control [19]. Calcium application has been reported to be effective in terms of membrane functionality and integrity maintenance as well as lower losses of phospholipids and proteins and also reduced ion leakage which could be responsible for the lower weight loss in plums [20].

Decay %: Data in Table 2 showed similar trend to that of weight loss rate as it cleared that the pre-harvest treatment with Ca $(NO_3)_2$ 2%, decreased the fruit decayed percentage under cold storage compared with control and other treatments effects. Regarding the effect of cold storage period, data in Table 2 cleared that fruit decay (%) gradually increased with prolonging the storage period in all treatments as well as control in both seasons. So, five days of cold storage period possessed the lowest values in this regard while the highest values were recorded at 30 days in both seasons. Regarding the effect of the interaction between storage period and pre-harvest treatments, data in Table 2 showed that the lowest decay (%) was gained by the interaction between remaining five days under cold storage and preharvest application with $Ca(NO_3)_2$ at 2%. Decay percentage of Crimson seedless grape variety was increased considerably with prolonged storage period in all treatments [17].

Firmness (lb/inch²): As shown in Table 3 it is clear that fruits firmness gradually decreased under cold storage in all treatments including control. In this regard, data presented in Table 3 cleared that fruits which were pre-harvest treated with Ca $(NO_3)_2$ at 2% possessed higher firmness values followed descendingly by Ca-EDTA at 1.5 %, $CaCl_2$ at 1.5 %, Zn SO_4 at 0.4% and by control treatment which gained the lowest values of firmness and experienced the faster loss of firmness up to 30 days in cold storage in both seasons. Fruit firmness, in general followed a declining trend with advancement in storage period [3,17,19]. The loss in fruit firmness parameter is considered to be one of the most important parameters of quality during transport, handling and storage [21]. The positive effect of calcium on maintaining fruit firmness may be due to the calcium binding to free carboxyl groups of polyglacturonate polymer, stabilizing and strengthening the cell wall [22].

Effect of Pre-Harvest Treatments on Chemical Characteristics,

Total Soluble Solids (T.S.S. %): Data in Table 4 cleared that total soluble solid (T.S.S. %) of fruits gradually increased under cold storage in all treatments

Table 1: Effect of some pre-harvest treatments on fruit weight loss % of Canino apricot under cold storage conditions during 2010 and 2011 seasons.

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	0	1.72	5.23	9.58	13.75	21.13	28.24	11.38
$CaCl_2$ 1.5 %	0	1.46	3.76	8.17	12.07	21.41	25.42	10.33
$Ca(NO3)_2$ 2%	0	1.33	3.60	7.26	11.95	18.61	24.36	9.59
Ca-EDTA 1.5 %	0	1.61	4.52	9.49	14.52	18.64	23.71	10.36
Zn SO_4 at 0.4%	0	1.83	4.61	9.47	14.82	21.29	25.70	11.10
Mean	0	1.56	4.12	8.60	13.34	19.99	24.80	10.35
LSD at 0.05	T=1.28			S = 1.52			T*S= 3.4	
				2011 season				
Control	0	2.23	5.34	10.56	14.06	20.95	32.97	12.30
$CaCl_2$ 1.5 %	0	1.73	3.70	8.29	14.09	20.36	26.61	10.68
$Ca(NO_3)_2$ 2%	0	1.43	3.67	6.25	12.22	18.31	26.58	9.78
Ca-EDTA 1.5 %	0	1.90	5.07	8.57	15.29	19.32	24.71	10.69
Zn SO_4 at 0.4%	0	1.87	5.00	10.06	16.32	21.97	28.23	11.92
Mean	0	2.36	5.46	9.79	15.33	20.99	28.18	11.07
LSD at 0.05	T=1.01			S = 1.20			T*S= 2.68	

T=Treatment, S= Storage period

Table 2: Effect of some pre-harvest treatments on fruit decay % of Canino apricot under cold storage conditions during 2010 and 2011 seasons

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	0	0	0	10.00	16.67	30.00	46.67	14.76
$CaCl_2$ 1.5 %	0	0	0	6.67	13.33	23.33	33.33	10.95
$Ca(NO3)_2$ 2%	0	0	0	3.33	10.00	20.00	30.00	9.05
Ca-EDTA 1.5 %	0	0	0	6.67	13.33	20.00	33.33	10.48
Zn SO_4 at 0.4%	0	0	0	10.00	16.67	26.67	40.00	13.33
Mean	0	0	0	7.33	14.00	24.00	36.67	11.71
LSD at 0.05	T=2.70			S= 3.25			T*S= 7.28	
				2011 season				
Control	0	0	0	13.33	23.33	33.33	46.67	16.67
$CaCl_2$ 1.5 %	0	0	0	10.00	16.67	26.67	33.33	12.38
$Ca(NO_3)_2$ 2%	0	0	0	6.67	6.67	23.33	30.00	9.52
Ca-EDTA 1.5 %	0	0	0	13.33	16.67	20.00	33.33	11.9
Zn SO_4 at 0.4%	0	0	0	10.00	20.00	30.00	43.33	14.76
Mean	0	0	0	10.67	16.67	26.67	37.33	13.05
LSD at 0.05	T=3.06			S = 3.62			T*S= 8.10	

Table 3: Effect of some pre-harvest treatments on firmness (lb/inch²) of Canino apricot fruits under cold storage conditions during 2010 and 2011 seasons

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	6.59	5.92	5.22	4.53	3.39	2.40	1.71	4.25
$CaCl_2$ 1.5 %	10.02	7.89	6.40	5.38	4.40	3.63	2.57	5.75
$Ca(NO3)_2$ 2%	12.48	10.43	8.84	7.13	5.70	4.56	3.11	7.46
Ca-EDTA 1.5 %	10.96	9.36	8.39	6.45	5.00	3.85	2.81	6.69
Zn SO_4 at 0.4%	8.86	6.90	6.08	4.61	3.94	3.40	2.22	5.15
Mean	9.78	8.10	6.99	5.62	4.49	3.57	2.48	5.86
LSD at 0.05	T=0.79			S = 0.93			T*S= 2.09	
				2011 season				
Control	7.58	6.63	6.05	5.42	3.84	2.98	1.51	4.86
$CaCl_2$ 1.5 %	9.31	8.49	7.78	6.60	4.97	3.79	2.31	6.18
$Ca(NO_3)_2$ 2%	12.70	11.93	11.28	10.29	8.06	6.12	3.87	9.18
Ca-EDTA 1.5 %	10.42	10.01	9.33	7.48	5.56	4.16	2.82	7.11
Zn SO_4 at 0.4%	9.15	8.60	7.49	6.33	4.79	3.80	2.16	6.05
Mean	9.83	9.13	8.39	7.22	5.44	4.17	2.53	6.68
LSD at 0.05	T=0.62			S = 0.74			T*S= 1.66	

T=Treatment, S= Storage period

Table 4: Effect of some pre-harvest treatments on (T.S.S. %) of Canino apricot fruits under cold storage conditions during 2010 and 2011 seasons

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	10.65	10.92	11.15	11.39	11.65	12.03	11.85	11.38
$CaCl_2$ 1.5 %	11.44	11.68	11.88	12.17	12.48	13.12	12.75	12.22
$Ca(NO3)_2$ 2%	12.52	12.83	13.11	13.34	13.61	14.14	13.91	13.35
Ca-EDTA 1.5 %	12.15	12.38	12.57	12.80	12.98	13.40	13.22	12.79
Zn SO_4 at 0.4%	11.32	11.63	11.98	12.20	12.46	13.00	12.70	12.18
Mean	11.62	11.89	12.13	12.38	12.64	13.14	12.89	12.38
LSD at 0.05	T=0.19			S = 0.22			T*S= 0.50	
				2011 season				
Control	10.01	10.3	10.52	10.81	11.39	11.82	11.32	10.88
$CaCl_2$ 1.5 %	10.52	10.91	11.24	11.54	11.92	12.66	12.25	11.58
$Ca(NO_3)_2$ 2%	12.05	12.3	12.66	12.94	13.15	13.89	13.54	12.93
Ca-EDTA 1.5 %	11.36	11.55	11.72	11.90	12.12	12.90	12.42	12.00
Zn SO_4 at 0.4%	10.91	11.13	11.30	11.51	11.69	12.08	11.85	11.50
Mean	10.97	11.24	11.49	11.74	12.05	12.67	12.28	11.78
LSD at 0.05	T=0.20			S = 0.23			T*S= 0.53	

T=Treatment, S= Storage period

Table 5: Effect of some pre-harvest treatments on total acidity (mg malic acid/100 ml juice) of Canino apricot fruits under cold storage conditions during 2010 and 2011 seasons

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	1.08	0.89	0.83	0.75	0.69	0.63	0.58	0.78
$CaCl_2$ 1.5 %	1.14	1.00	0.90	0.84	0.68	0.70	0.65	0.84
$Ca(NO3)_2$ 2%	1.55	1.37	1.22	1.05	0.87	0.78	0.66	1.07
Ca-EDTA 1.5 %	1.15	1.05	0.99	0.92	0.86	0.80	0.74	0.93
Zn SO_4 at 0.4%	1.26	1.15	1.01	0.95	0.89	0.81	0.74	0.97
Mean	1.24	1.09	0.99	0.90	0.80	0.74	0.67	0.92
LSD at 0.05	T=0.04			S = 0.04			T*S= 0.11	
				2011 season				
Control	1.12	0.95	0.91	0.86	0.79	0.72	0.65	0.86
$CaCl_2$ 1.5 %	1.31	1.19	1.08	0.97	0.68	0.79	0.70	0.96
$Ca(NO_3)_2$ 2%	1.43	1.32	1.19	1.03	0.94	0.86	0.78	1.08
Ca-EDTA 1.5 %	1.22	1.07	0.96	0.87	0.79	0.74	0.68	0.90
Zn SO_4 at 0.4%	1.22	1.12	1.01	0.92	0.83	0.79	0.73	0.95
Mean	1.26	1.13	1.03	0.93	0.81	0.78	0.71	0.95
LSD at 0.05	T= 0.08			S = 0.10			T*S= 0.23	

T=Treatment, S= Storage period

Table 6: Effect of some pre-harvest treatments on TSS/acid ratio of Canino apricot fruits under cold storage conditions during 2010 and 2011 seasons

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	11.57	14.46	15.94	17.83	19.75	19.09	20.43	17.01
$CaCl_2$ 1.5 %	10.10	11.66	13.18	14.49	16.44	18.74	19.61	14.89
$Ca(NO3)_2$ 2%	6.88	8.19	9.19	10.89	13.38	18.12	21.07	12.53
Ca-EDTA 1.5 %	11.56	11.78	12.70	13.86	15.11	16.75	17.86	14.23
Zn SO_4 at 0.4%	9.89	10.15	11.94	12.89	13.91	16.04	17.16	13.14
Mean	10.00	11.25	12.59	13.99	15.72	17.75	19.23	14.36
LSD at 0.05	T=0.67			S = 0.80			T*S= 1.70	
				2011 season				
Control	10.77	12.89	13.86	14.98	16.66	15.81	17.41	14.63
$CaCl_2$ 1.5 %	8.18	9.42	10.71	12.17	13.69	15.08	17.50	12.39
$Ca(NO_3)_2$ 2%	7.01	7.85	8.92	10.65	12.39	15.29	17.35	11.35
Ca-EDTA 1.5 %	9.15	10.88	12.27	13.70	15.35	16.37	18.26	13.71
Zn SO_4 at 0.4%	9.06	10.06	11.21	12.79	14.28	14.79	16.23	12.63
Mean	8.83	10.22	11.39	12.86	14.47	15.47	17.35	12.94
LSD at 0.05	T=0.97			S = 1.15			T*S= 2.59	

T=Treatment, S= Storage period

Table 7: Effect of some pre-harvest treatments on fruit total sugars (%) of Canino apricot under cold storage conditions during 2010 and 2011 seasons

	Storage periods(days) under 0°C							
	2010 season							
Treatments	0	5	10	15	20	25	30	Mean
Control	6.77	6.76	7.09	7.46	7.71	8.80	8.21	7.54
$CaCl_2$ 1.5 %	6.87	7.27	7.78	8.32	8.77	9.57	9.12	8.24
$Ca(NO_3)_2$ 2%	8.17	8.59	8.99	9.42	9.58	10.0	9.84	9.23
Ca-EDTA 1.5 %	7.07	7.74	8.11	8.57	9.00	10.02	9.33	8.55
Zn SO_4 at 0.4%	7.18	7.01	7.31	7.55	7.80	8.48	8.11	7.63
Mean	7.21	7.47	7.86	8.26	8.57	9.37	8.92	8.24
LSD at 0.05	T=0.31			S = 0.37			T*S= 0.83	
				2011 season				
Control	6.56	6.97	7.24	7.47	7.69	8.18	7.97	7.44
$CaCl_2$ 1.5 %	7.14	7.53	7.73	7.91	8.12	8.66	8.35	7.92
$Ca(NO_3)_2$ 2%	7.63	7.98	8.24	8.48	8.86	9.69	9.14	8.57
Ca-EDTA 1.5 %	7.66	7.96	8.19	8.39	8.58	9.74	8.94	8.49
Zn SO_4 at 0.4%	7.04	7.26	7.51	7.74	7.97	8.4	8.20	7.73
Mean	7.21	7.54	7.78	8.00	8.24	8.93	8.52	8.03
LSD at 0.05	T=0.37			S = 0.44			T*S= 0.99	

T=Treatment, S= Storage period

including control up to 25 days then decreased in all treatments in both seasons. In this regard, data presented in Table 4 indicated that pre-harvest treating of the fruit with $Ca(NO_3)_2$ at 2% resulted in an increase of TSS percentages followed descendingly by Ca-EDTA at 1.5 %, $CaCl_2$ at 1.5 %, Zn SO_4 at 0.4% and control treatment which possessed the lowest values of TSS % in both seasons. This increase in TSS percentage may be due to water loss during storage [23]. Fruit chemical quality of grape berries were positively affected with pre-harvest treatments of Ca and Zn [17]. Also, data in Table 4 cleared that remaining Canino apricot fruits twenty five days under cold storage in addition to Ca $(NO_3)_2$ at 2% showed to be the most effective treatment in inducing high TSS percentage in both seasons [3]. The increase in TSS during cold storage may possibly be due to hydrolysis of starch into sugars. As the hydrolysis of fruit starch is completed, no further increase in TSS could be detected and subsequently a decline in this parameter is predictable since sugars along with other organic acids are primary substrates used for respiration [24].

Total Acidity% and TSS/Acid Ratio: Data in Tables 5 and 6 showed that total acidity % of fruits gradually decreased under cold storage in all treatments including control to attain the minimum at the end of storage period during the two seasons of the study. However, the decrease of total acidity during cold storage was more rapid and faster in control which indicated that total acidity degradation was occurred gradually in the treated fruits under cold storage. Generally, the lowest values of fruit acidity were recorded after remaining thirty days under cold storage in both seasons. The lowest percentage of total acidity was recorded in control, whereas the highest total acid content was observed in the fruits treated with Ca $(NO_3)_2$ at 2%. The decrease in total acidity during ripening and storage may be attributed to the increase in malic and pyruvate decarboxylation reaction during the climacteric period [25] or may be due to the metabolic changes in fruits or due to the use of organic acids in respiratory process [26]. Also, papaya fruits treated with calcium chloride maintained higher acidity during storage and this may be due to the delay in ripening process [27]. Regarding to TSS/acid ratio, data in Table 6 showed that the TSS/acid ratio was increased in all treatments under cold storage. The maximum increase was gained from the control fruits, while the least ratio was obtained from application of Ca $(NO_3)_2$ at 2%. Similar results on grape were obtained by Abdel-Hamid [28], Abdel-Hamid *et al*. [29] and Morga *et al*. [30].

Total Sugars (%): Data in Table 7 showed that as in TSS parameter, the maximal total sugars content of fruits were gained from fruits treated with $Ca(NO_3)_2$ at 2% while the

minimal fruit total sugars content were recorded by control fruits and Zn SO_4 at 0.4% in both seasons. Total sugars content of fruits were gradually increased in all treatments including control under cold storage up to 25 days then decreased in all treatments in both seasons. The increase in total sugars percentage during cold storage may possibly due to the hydrolysis of starch into sugars. As hydrolysis of starch into sugars is completed, no further increase in total sugars percentage occurs and subsequently a decline in this parameter is predictable [24]. Total fruit sugars as well as organic acids considered as primary substrates for respiration. The increase in fruit sugars content during the early stages of cold storage may be attributed to the reduction in moisture content, degradation of complex insoluble compounds to simple soluble compounds and accumulation of sugars in fruit juice [30].

It could be concluded that mature Canino apricot fruits pre-harvest treated with calcium nitrate $Ca(NO_3)_2$ at 2% can be stored at 0°C and 90-95% RH for thirty days with acceptable quality.

REFERENCES

1. FAOstat.fao.org/site/567/DesktopDefault.aspx faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor
2. Egea, M.I., M.C. Martinez-Madrid, P. Sanchez-Bel, M.A. Muricia and F. Romojaro, 2007. The influence of electron-beam ionization on ethylene metabolism and quality parameter in apricot (*Prunus armeniaca* L., cv Builda). Swiss Soc. Food Sci. Technol., 40: 1027-1035.
3. El-Badawy, H.E.M. and F.T.A. El-Salhy, 2011. Physical and chemical properties of Canino apricot fruits during cold storage as influenced by some post-harvest treatments. Australian J. Basic and Applied Sciences, 5(9): 537-548.
4. Gerasopoulos, D. and P.D. Drogoudi, 2005. Summer-pruning and preharvest calcium chloride sprays affect storability and low temperature breakdown incidence in kiwifruit. Post Harvest Biol. Techno., 36: 303-308.
5. Rizk-Alla, S. Mervat, V.H. Girgis and A.A. Abd EL-Ghany, 2006. Effect of foliar application of mineral or chelated calcium and magnesium on Thompson seedless, grapevines grown in a sandy soil. B: Fruit quality and keeping quality during storage at room temperature. J. Agric. Sci. Mansoura Univ., 31: 3079-3088.
6. Goncalves, N.B., V.D. De Carvalho and J.R. Goncalves, 2000. Effect of calcium chloride and hot water treatments on enzyme activity and content of phenolic compounds in pineapple. Pesquisa Agrop. Brasil, 35: 2075-2081.
7. White, P.J. and M.R. Broadley, 2003. Calcium in plants. Ann. Bot., 92: 487-511.
8. Lu, C.W. and S.R. Duyang, 1990. The effect of preharvest calcium sprays on the storage life of table grapes. Acta Horticulturae Sinica, 7(2): 103-110. Hort. Abst, 62: 8124.
9. Satour, R.F.S., 2010. Improving post-harvest quality and marketability of Anna apple fruits in response to some chemicals preharvest sprays. M.Sc Thesis. Fac. of Agric, Alexandria University, pp: 113.
10. Peryea, F.J. and G.H. Neilsen, 2006. Effect of very high calcium sprays just before harvest on apple fruit firmness and calcium concentration. Acta Hort., 721: 199-205.
11. Mohsen, A.T., 2004. Response of Canino apricot trees to some dormancy breaking agents. II: Effect of fruit quality and its cold storage ability. Egyptian J. Applied Sci., 19: 362-381.
12. McCormack, A.A. and C.V. Broun, 1973. Market disease and blemishes of Florida fruits. Department of citrus lake Alfred State of Flo. Dept. of Citrus.
13. Smith, F., M.A. Gilles, J.K. Hamilton and P.A. Godess, 1956. Colorimetric method for determination of sugars related substances. Anal. Chem., 28: 350-356.
14. A.O.A.C. 1985. Association of Official Analytical Chemists. Official Methods of Analysis 14th Ed. Washington D.C, USA. pp: 382.
15. SAS, Statistical Analyses System, User's Guide: Statistics (Version 6.11 windows), SAS institute Inc, Cary, NC (1989).
16. Subbramu, K., M. Singaravelu, A. Nazar and I. Irulapan, 1990. Pre-harvest spray of calcium in grapes. South Indian Horticulture, 38(5): 268-269. Hort. Abstr, 62: 8125.
17. Abdel-Wahab, S.M. and I.E. El-Shinawy, 2004. Effect of some pre-harvest treatments on improving quality and storability of Crimson seedless grapes. Annals of Agric. Sci. Moshtohor, 42(4): 1965-1981.
18. Abdrabboh, G.A. and A.M. Abdel-Razik, 2009. Effect of nitrogen source on fruit quality of Superior seedless grapevine under cold storage conditions. Annals of Agric. Sci., Moshtohor, 47(2): 317-326.

19. Mahajan, B.V.C., B.S. Ghuman and Harsimrat K. Bons, 2011. Effect of post-harvest treatments of calcium chloride and gibbrellic acid on storage behavior and quality of Guava fruits. J. Hort. Sci. & Ornamental Plants, 3(1): 38-42.
20. Lester, G.E. and M.A. Grusak, 1999. Postharvest application of calcium and magnesium to honeydrew and netter muskmelons: Effects on tissue ion concentrations, quality and senescence. J. Am. Soc. Hort. Sci., 124: 545-552.
21. Shear, C.B., 1975. Calcium related disorder of fruit and vegetable. HortScince, 10: 361-365.
22. Conway, W.S. and C.E. Sams, 1983. Calcium infiltration of Golden delicious apples and its effect on decay. Phytopathol., 73: 1068-1071.
23. Hifny, H. A. A. and R.S. Abdel-All, 1977. Effect of GA and CCC on physical and chemical changes in seedless grapes under cold storage conditions. Vitis, 16(1): 27-31.
24. Wills, R.B.H., P.A. Bembndge and K.J. Scott, 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of Delicious apples. Aust. J. Exp. Agric. and Aram, 20: 252-256.
25. Rhodes, M.J.C., L.S.C. Wood Orton, T. Gallardo and A.C. Hulme, 1968. Metabolic changes in excised fruit tissue I. Factors affecting the development of a malate decarboxylation system during the ageing of disc of pre-climacteric apples. Phytochemistry, 7: 439.
26. Echeverria, E. and J. Valich, 1989. Enzymes of sugar and acid metabolism in stored *Valencia oranges*. J. Am. Soc. Hort. Sci., 114: 445-449.
27. Mahmud, T.M.M., A. Al Eryysni-Raqeeb, S.R. Sayed Omar, A.R. Mohmad Zaki and A.R. Al-Eryan, 2008. Effect of different concentrations and application of calcium on storage life and physicochemical characteristics of papaya. Am. J. Agric. Biol. Sci., 3: 526-533.
28. Abdel-Hamid, N., 2000. Pre-harvest application of some ethylene inhibitors delays "Crimson seedless grape ripening and improves storability. Annals Agric Sci., Ain Shams Univ. Egypt, 45(1): 295- 314.
29. Abdel-Hamid, N., Sh. M. Selem, G.F. Ghobreial and K.H. Abd El-Aziz, 2004. Effect of different Nitrogen doses and bio-fertilizers application on yield and quality of Crimson seedless grapes. J. Environ. Sci., 8(3): 837-861.
30. Morga, N.S., A.O. Lustre; M.M. Tunac, A.H. Balogot and M.R. Soriano, 1979. Physiochemical changes in Philippine caraboa mangoes during ripening. Food Chemistry, 4: 225-234.