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Apricot Postharvest Fruit Quality, Storability and Marketing in Response to Pre harvest Application

Sahar. M. Abd El Wahab

Department of Pomology, Faculty of Agriculture, Cairo University, Giza, Egypt

ABSTRACT

Influence of pre-harvest application of amino acids, putrescine, salicylic acid or ascorbic acid + citric acid all with addition to calcium nitrate on the yield, storability and market life of "Canino" apricot fruits were investigated. All treatments were done at just after fruit setting and repeated 2 times at 15 days intervals. The Sprayed fruits were stored up to 4weeks at 0 °C and 90–95% R H and fruit quality was evaluated at harvest, during cold storage and after 5 days as market-life. Results showed that weight loss, total soluble solids, total sugars content and respiration rate increased whereas, firmness, total acidity, vitamin c and total phenols decreased by increasing storage and marketing periods. All treatments increased fruit weight and yield at harvest, during storage periods decreased decay, weight loss and delayed the changes in firmness, total acidity, total soluble solids, vitamin C, total sugars, total phenols and respiration rate compared with control. The best results of market life obtained by pre harvest treatments. The study suggests that these treatments might be a promising candidate as maintain apricot quality and also to get a product safe and healthy, especially during cold storage and marketing, thus extending post- harvest life of apricot.

Key words: Apricot, pre-harvest sprays, calcium, putrescine, amino acids ,ascorbic acid, citric acid, cold storage, marketing -life

Introduction

Apricot (*Prunus armeniaca*, L.) belongs to family Rosaceae is one of the most important fruit crops of temperate region of the world. "Canino" apricot is one of the most important cultivar grown in newly reclaimed lands in Egypt. The main factors limiting postharvest life of apricot fruits are excessive softening and highly perishable led to rapid deterioration and short handling period in markets which limits its commercial potential. For the enhancement of their postharvest life along with quality, it is necessary to use pre harvest treatments of different agrochemicals that may led to relate fruit physiology to ripening and senescence, maintain apricot fruits with high quality for longer time in markets or after storage for a certain period.

Calcium salts used to increase Ca content of the cell wall fruits. Pre harvest and postharvest calcium application have been effective in controlling of several physiological disorders in various fruits like strawberry, peaches, nectarines and apples (Dunn and Able, 2006),reduced the incidence of fungal pathogens and maintaining fruit firmness, reduced the respiration rate at harvest stage, delaying senescence ,ripening and resulting in higher quality fruit (Raese and Drake, 2006).Calcium significantly improved maintenance of fruit firmness decreased the weight loss, showed higher levels of TA and lowered contents of SSC % , slightly maintained the loss of ascorbic acid of papaya fruits (Mahmud *et al*., 2008). Pre Harvest application Calcium nitrate at 2% was the best treatment for improving fruit quality as reduce weight loss, decay and increased firmness and acidity under cold storage conditions of apricot fruits
(Abdrabboh, 2012*)*. Also (El-Shazly *et al*., 2013) reported that pre harvest application calcium chloride significantly increased yield, firmness and acidity of peach fruits.

Amino acids as organic nitrogenous compounds are the building blocks in the synthesis of proteins in plants and regulates the plant metabolism (Davies,1982). Amino acids can directly or indirectly influence the physiological activities in plant growth and development. Moreover, the exogenous application of amino acids have been reported to modulate the growth, improve fruit weight, yield and fruit quality (Fayek *et al*.,2011) of Le Conte pear, (Khan *et al* .,2012) of Perlette, Red Globe grapes, (Abd El-Razek and Saleh,2012) of 'Florida Prince' peach. Also, **(**Ahmed *et al.,* 2014) of El- Saidy date palm.

Putrescine (as one of the polyamine group) has shown its functions inhibit ethylene production and delay fruit ripening in apricot (Metha *et al*., 2002). Putrescine decrease respiration rate of peach (Bale,2013) and reduce senescence rate after harvest ,reduced fruit deterioration, respiration rate and improving fruit quality, increasing marketability and storability of apricot (Martínez-Romero *et al* ., 2002) and preserved sugar in mangoes(Malik *et al* ., 2003). Polyamines (PAs) promoted fruit set and retention in apricot (Ali *et al*., 2010)

Corresponding Author: Sahar. M. Abd El Wahab, Department of Pomology, Faculty of Agriculture, Cairo university, Giza, Egypt.
E-mail: saharwahab5@yahoo.com

.Putrescine significantly increased fruit firmness, reduced fruit soluble solids concentration (SSC) of plum fruits (Khan and Singh, 2010) and (Bal,2013) of Peach. Putrescine reduced significantly the weight loss and maintained the firmness, gave the highest titratable acidity, ascorbic acid, total phenol of apricot (Davarynejad *et al* .,2013).Putrescine has a regulatory role in increasing yield ,fruit weight , improving fruit quality of apricot (Ali *et al* ., 2010) and (Ali *et al* .,2014) of peach.

Salicylic acid is an endogenous growth regulator from phenolic group, which participates in the regulation of several physiological processes in plants such as growth and development (Asghari and Aghdam, 2010).Using salicylic acid was very effective in enhancing fruit weight and yield and fruit quality of different fruit crops (Abd El-Razek *et al*., 2013) on olive**,** (El-Shazly *et al*., 2013) on peach. Several studies have recorded the important role of pre and postharvest salicylic acid applications of improving fruit quality parameters such as delay the decline of ascorbic acid content of pineapple fruit(Lu *et al.,* 2011)decrease ethylene production and delayed the ripening process in kiwifruit(Mohammadi and Aminifard, 2013). SA increased storability and lower weight loss and fungal decay and has positive effect on firmness, total phenol contents delay the fruit senescence of peach fruits (Khademi and Ershadi, 2013) and had significantly increased firmness and acidity of peach fruits (El-Shazly *et al*., 2013) and maintained greater firmness reduced T.S.S and fruit losses during cold storage and extend postharvest life of peach (Awad ,2013). salicylic acid reduced total sugars, respiration rate, water loss, decay percentage and maintained fruit firmness in stored mango fruit(Abd El-Monem *et al* .,2013) and reduce water loss ,fungal decay ,softened and increase total phenol compound and storage Life of grape (Mohamed and Mehdi,2014).

Antioxidants such as Ascorbic acid, citric acid have auxinic action and also synergistic effect on flowering and fruiting of fruit trees of most fruit trees, recently antioxidants used instead of auxins and other chemicals for enhancing growth and fruiting of various fruit trees (Ragab, 2002). In addition, the positive action of antioxidants in catching or chelating the free radicals which could result in extending the shelf life of plant cells and stimulating growth aspects is reported (Rao *et al .,*2000). Previous studies showed that using antioxidants in different fruit crops was very effective in improving growth ,yield and fruit quality of fruit crops trees(Maksoud *et al .,*2009) of olive, (Fayed,2010)of pomegranate,(Ibrahim *et al*., 2013) of Zaghloul Date Palms and (Fayek *et al* .,2014) of Le Conte pear .Also , Hafez *et al* .(2010) reported that antioxidants such as ascorbic acid, citric acid decreased the decay, weight loss and fruit softening during cold storage and marketing period of Le Conte pear.

Therefore, the present study was conducted to evaluate the influence of pre-harvest application of putrescine, amino acids, salicylic acid, (ascorbic acid + citric acid) addition to calcium nitrate on fruit weight, yield and quality properties of "Canino" apricot fruits during 28 days cold storage and 5 days as market-life under ambient conditions.

Material and Methods

Fruit material:

Apricot tress (*Prunus armeniaca*, L.) of eight years old and grown in private farm located in El-Kattatba, Menofya Governorate were the material of this study at the two seasons (2013and 2014). Trees were planted at 5x5 meters (160 tree/Fadden) budded on local apricot in sandy soil under drip irrigation system and received the common cultural practices. Forty five Trees used in the experiment were selected to be healthy and as uniform as possible. Four treatments beside the control were investigated. Each treatment contained 3 replicates each had 3 trees. Randomized complete block design was followed in this investigation .The trees were sprayed three times at just after fruit setting (the last week of March) and repeated 2 times at 15 days intervals. Control trees sprayed with water only.Tween-20 (0.1%) as surfactant was added to all spraying solutions (5litre for tree) and applied directly for the trees with a handheld sprayer until runoff in the early morning.

Pre harvest treatments as follows:

1-Control (sprayed with water)

2-50ppm Ascorbic acid (ASA) +50ppmCitric acid (CIA) + (2% w/v) Calcium nitrate Ca $(No_3)_2$

3-4 mmol / L Putrescine (PUT) + (2% w/v) Calcium nitrate Ca $(No_3)_2$

4-2 mmol /L Salicylic acid (SA) + (2% w/v) Calcium nitrate Ca $(No_3)_2$

5-Aminolom Contrasal at 0.05% (as a commercial name, liquid formula containing11% rich collection of free amino acids and 15.6% calcium nitrate).

Apricot fruits were hand harvested from each treatment at predictable maturity (in the middle of May) in both seasons (2013-2014) when fruits of covered color and flavor as described by Mohsen (2004). Samples of 15 mature fruits were taken from each replicate of each treatment at the harvest date for determining average fruit weight and fruit quality. Fruit yield (kg)/tree for each treatment was estimated in both seasons. Fruits transported to the laboratory were without any signs of mechanical damage or deterioration and selected with homogeneous size, color and form**.**

Fruit storage:

Treated fruits were rapidly and carefully were placed in three performed cartoon boxes (30×40×20 cm) for each treatment, the first box to determine decay, the second to determine weight loss and the third to determine fruit quality parameters every 1 week during 4 weeks period at different sampling time i.e 7,14,21 and 28 days of cold storage. Each box contained 2 kg was replicated three times, and the experiment was repeated twice (2013 and 2014 seasons). Boxes of all treatments were stored at 0ºC and 90-95% RH in Post harvest laboratory of refrigeration, Agriculture Development Systems (ADS) project in the Faculty of Agriculture, Cairo University.

Quality Assessments of Fruit:

Determination of physical and chemical properties:

Fruit samples in all experimented treatments were subjected to series of quality evaluation during cold storage and after market life period (5 days)

Decay percentage:

The percentage of disordered fruits included all of the spoiled fruits resulted from rots, fungus, bacterial and pathogens were assessed and the defects were calculated as follows:

$$Decay\ \% = \frac{No.of\ fruit\ decay}{No.of\ fruit\ at\ the\ begining\ of\ storage}\ X\ 100$$

Weight loss percentage:

The difference between the initial weight of the fruits and that recorded at the date of sampling was translated as weight loss percentage and calculated as follows:

$$\text{Weight loss\%} = \frac{\text{Weight loss in (g.)}}{\text{The initial weight of the fruits at the beginning of storage (g.)}}\ \text{X 100}$$

Fruit Firmness (lb/in^2):

It was measured on the two opposite sides of apricot fruit samples by using a hand Magness Taylor pressure tester (lb/in^2).

Total Soluble Solids (TSS) %:

Individual apricot fruits were ground in an electric juice extractor for freshly prepared juice. Soluble solids content was measured using Digital rafractometer PR32 (0.32% Atago Palete ATago.CO .LTD. Japan.

Total Acidity (TA) %:

Total acidity (expressed as malic acid %) was determined by titrating 5-ml juice with 0.1N sodium hydroxide using phenolphthalein as indicator (A.O.A.C., 2000).

Vitamin C (L- Ascorbic Acid) (mg/ 100 g. F. W.):

It was measured using 2, 5-6 dichlorophenol indophenols' method described by A.O.A.C. (2000).

Total sugars (mg/g F.W.):

By using the phenol-sulphuric acid method according to Dubois *et al* . (1956).

Total phenols (mg /g F .W):

By using folin – ciocalteu calorimetric method (Swain and Hillis, 1959) at the wave length of 725 nm, standard curve from p-hydroxyl benzoic acid was used to calculate the amount of phenols as mg per g fresh weight.

Respiration rate:

Individual fruits for each treatment were weighed and placed in 2-liter jars at room temperature (23°C ± 1). The jars were sealed for 3 h with a cap and a rubber septum. Air samples of the headspace were removed from the septum with a syringe and injected into Servomex Inst. Model 1450C (Food Pack Gas Analyzer) to measure oxygen content and carbon dioxide production. Respiration rate was evaluated at harvest day and during cold storage period (4 weeks) .Respiration rate was calculated as ml CO_2 /kg/h (Lurie and Pesis, 1992).

Marketing life:

After 4 weeks storage period,10 fruits of each replicate treatments were kept at (23°C ± 1) for 5 days, 75% RH in room temperature as marketing life to simulate the market condition, quality measurements as physiochemical properties of fruits were studied.

Experimental design and statistical analysis:

All results of physiochemical parameters were performed in triplicate using completely randomized factorial design and yield, fruit weight and marketing life using completely randomized design. Data were analyzed with the Analysis of variance (ANOVA) procedure of MSTAT-C program. When significant differences were detected, treatment means were compared by LSD range test at the 5% level of probability in the two investigated seasons (Snedecor and Cochran, 1980).

Result and Discussion

Fruit weight and Yield:

Data in Table (1) show that the use of per harvest application played a significant influence on increasing fruit weight and the fruit yield (Kg) per tree. Moreover, The highest significant values of fruit yield and fruit weight were recorded in "Canino" apricot trees sprayed with amino acids + calcium nitrate (Aminolom Contrasal) followed by antioxidants as (ascorbic acid + citric acid)+calcium nitrate then putrescine+ calcium nitrate and salicylic acid+ calcium nitrate compared with the control as it gave the lowest values of fruit weight and fruit yield in both seasons. The increase in fruit weight and yield of "Canino" apricot obtained by commercially available amino acids may due to thus important roles in enhancing proteins, natural hormones and organic foods biosynthesis as well as stimulating cell division (Sies, 1997) and hence increase fruit weight and apricot yield .The positive effect of antioxidants as(ascorbic acid +citric acid) was participate in fruit development through their positive action on enhancing the biosynthesis of natural hormones, nutrient uptake, photosynthesis and biosynthesis of sugars (Rao *et al*., 2000),therefore antioxidants were used instead of auxins and other chemicals for enhancing growth and fruiting of various fruit trees (Ragab, 2002).Meanwhile , putresine had role in promoting retention of apricot (Ali *et al*., 2010). While Salicylic acid (SA) was involved in regulating many processes regarding plant growth and development (Asghari and Aghdam, 2010) and additional calcium nitrate to amino acid or putresine or antioxidants or Salicylic acid led to significant increase in fruit weight and yield of "Canino" apricot. Previous studies showed that using Ca (El-Shazly *et al* .,2013)on peach ,using amino acids (Ahmed *et al. ,* 2014) on date palms, (Abd El-Razek and Saleh,2012) on peach, (Khan *et al*.,2012) on Perlette ,Red Globe grapes, using antioxidants (Maksoud *et al .,*2009) on olive ,(Fayed,2010)on pomegranate, (Ibrahim *et al*., 2013) on Zaghloul Date Palms and (Fayek *et al*.,2014) on Le Conte pear ,using PUT on apricot (Ali *et al* ., 2010), (Ali *et al* .,2014) on peach and using salicylic acid (Abd El-Razek *et al*., 2013) on olive and El-Shazly *et al* .(2013) on peach, as they were very effective in improving growth and yield.

Table1: Effect of pre harvest treatments on fruit weight and yield of 'Canino' apricot fruits during two seasons

Treatments (T)	2013 Season		2014 Season	
	Fruit weight (g)	Total yield (kg)	Fruit weight (g)	Total yield (kg)
Control	30.11	28.150	31.45	29.200
Ascorbic +citric acids +Ca	40.17	36.300	42.90	37.800
Putrescine+Ca	39.80	34.900	41.40	35.450
Salicylic+Ca	38.60	33.600	40.30	34.960
Amino acids +Ca	42.20	37.800	45.60	41.600
L.S.D. at 5%	0.07	0.071	0.07	0.080

ASA = Ascorbic acid *CIA= Citric acid* *Ca= Calcium nitrate*

Decay:

Data in Table (2) show that the all pre harvest treatments with added calcium nitrate reduced decay in all storage periods as putrescine or salicylic acid were the best treatments, followed by amino acids then antioxidants (ascorbic acid citric acid) in descending order as compared with control treatment under study. Moreover, the percentage of decayed fruits increased gradually with prolonging storage period as previously recorded by Ghasemnezhad *et al*. (2010). As for the effect of interaction between the tested pre harvest treatments and storage periods, i.e. 7, 14, 21 and 28 days the control treatment had higher decay percentage at 28 days storage but Putrescine+2% calcium nitrate had the lowest decay percentage in both seasons. As for, market life after 5 days from cold storage, the best treatment for keeping fruits at good characters during marketing was putrescine+ Ca. Conversely, control caused the highest decay% at marketing period in the two seasons. These results show that addition calcium nitrate gave better effect in reducing decay when add to putrescine or salicylic acid or amino acids or antioxidants (ascorbic acid+ citric acid). Marketing life is most influenced by contamination with microorganisms. Fruits treated had the best marketability that may be due to Ca induced high fruit resistance for fungi prevented physiological disorders during storage (Dunn and Able, 2006) while putrescine , amino acid ,SA and antioxidants lowered decay rate may be related with higher levels of antioxidant enzymes during storage leading to improved storability and extend market life of apricot. The present results go in parallel to calcium salts decrease decay of apricot fruit under cold storage and market life (Abdrabboh ,2012) .Applied putrescine reduced fruit deterioration , increasing storability and marketability some crops such as apricot (Martínez-Romero *et al* ., 2002) and Peach (Bal,2013). SA reduced fungal decay and increase storage in grape (Mohamed and Mehdi, 2013) and (Khademi and Ershadi ,2013) in peach .Also, antioxidants decrease decay during cold storage and market life of le conte pear (Hafez *et al* .,2010) and this led to improve storability of apricot fruits.

Table 2: Effect of pre harvest treatments on decay %of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	market life after 5 days (M)	0	1	2	3	4	Mean	market life after 5 days (M)
Control	0.00	3.40	7.90	16.60	29.60	11.50	38.73	0.00	3.90	6.85	13.90	27.80	10.49	35.23
ASA+ CIA +Ca	0.00	0.90	3.90	7.80	13.20	5.15	16.10	0.00	0.00	3.80	7.10	12.80	4.74	15.85
Putrescine+Ca	0.00	0.00	1.80	4.80	10.10	3.34	13.22	0.00	0.00	1.65	4.30	9.60	3.11	11.40
Salicylic acid+Ca	0.00	0.00	2.50	6.00	11.45	3.99	14.55	0.00	0.00	2.00	5.20	10.90	3.62	13.47
Amino acids +Ca	0.00	0.20	3.35	6.50	11.95	4.40	15.14	0.00	0.00	3.10	5.75	11.20	4.00	14.56
Mean	0.00	0.90	3.89	8.34	15.26	-	-	0.00	0.78	3.48	7.25	14.46	-	-
L.S.D. at 5%	Treatments (T) = 0.04 Storage period (P) = 0.03 Interaction(T)x (P) = 0.05 Market life (M) = 0.07							Treatments (T) = 0.03 Storage period (P) = 0.03 Interaction(T)x (P) = 0.04 Market life (M) = 0.06						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Weight loss:

Data in Table (3) show that there were a significant difference (p<0.05) between treatments and control in terms of their effects on weight loss. The highest values of weight loss were obtained in "Canino" apricot control fruits. These results hold true in the two seasons., the lowest weight loss percentage was recorded in sprayed fruits with pre harvest treatments as putrescine+ Ca, salicylic acid + Ca, amino acids + Ca, ascorbic acid +citric acid + Ca in descending order. Meanwhile, loss in fruit weight increased significantly as storage period advanced and the highest loss of weight was obtained at the end of storage. Similar results were also reported by (Davarynejad *et al* .,2013).The interaction between pre harvest treatments and storage periods, referred that the lowest values for weight loss at different storage period i.e., 1,2,3 and 4 weeks of storage were significant in pre harvest application specially in putrescine+ Ca maintaining more fruit weight until ending stage of storage . In addition, weight loss percentage showed a trend of increase during the market life period (5 days after cold storage) in all treatments, meanwhile pre harvest treatments showed the lowest weight loss of apricot fruit during the market life. The decrease in weight loss may due to respiration and transpiration (Wolucka *et al.*, 2005).Calcium plays a role in reducing the respiration (Raese and Drake, 2006) and when added to putrescine or SA or amino acid or antioxidants with cold storage reduced transpiration in fruits and thus led to minimize the impact of weight loss of apricot fruits and this led to improve storability of apricot fruits. Similar results have been reported by (Mahmud *et al*., 2008) on calcium, (Martínez-Romero *et al*., 2002) on putrescine (Put) and Abd El-Monem *et al*. (2013) on SA in decreasing respiration rate. Also, Abdrabboh (2012)on calcium nitrate, Davarynejad *et al*. (2013) on putrescine and Abd El-Monem *et al*. (2013)and Mohamed and Mehdi (2014)on salicylic in decreasing weight loss .

Fruit firmness:

As shown in Table (4) all pre harvest treatments resulted significantly highest firmness whereas the highest fruit softening rate was recorded in control treatment. During all storage period, it is cleared that as Putrescine+ Ca, salicylic acid + Ca, amino acid + Ca and (ascorbic acid at +citric acid) + Ca treatments retained maximum fruit firmness as compared with control in both seasons of study. Fruit firmness decreased gradually and significantly with the progress of cold storage in both seasons, a result supported the finding of Davarynejad *et al*. (2013). The most firm was found in treated fruits that could be due to the addition of calcium nitrate to treatments that could be responsible for the higher pulp firmness observed at harvest and also at the end of storage compared to control. A significant role has been proposed for calcium in conferring mechanical strength on the cell wall, as a result of its binding to pectin to form calcium pectate, which increases the rigidity of the middle lamella of the cell wall (Conway *et al.*, 1997). The potential role calcium in increasing firmness of fruit was by the cohesion of cell-walls (Kazemi *et al.*, 2011)and thus it contribute to the linkages between pectin substances within the cell-wall (Arhtar *et al* ., 2010). Also role of pre harvest treatments as inhibition of the action of wall-degrading enzymes, this led to increasing hardness at harvest till 28 days of cold storage which enhanced fruit handling and storability. While the control plants (without receiving pre harvest treatment) had the softest fruits as no market life and shipment capability. In response to fruit firmness, it is clear that firmness showed a trend of decrease with the extending of storage period and further 5 days during market life. Control fruits presented the lowest significant values, while fruits from trees treated with pre harvest treatments produced the highest positive effect on firmness at both seasons. The incensement in fruit firmness during cold storage was stated by Abdrabboh (2012*)*on Calcium nitrate, Davarynejad *et al* . (2013) on putrescine, Khademi and Ershadi (2013); El-Shazly *et al.*(2013) on salicylic acid and Hafez *et al* . (2010) on antioxidants and this led to improve storability of apricot fruits.

Table 3: Effect of pre harvest treatments on Weight loss% of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	0.00	4.25	7.10	9.73	15.20	7.25	22.60	0.00	3.70	5.90	7.90	13.50	6.20	21.80
ASA+ CIA +Ca	0.00	2.90	3.90	5.25	6.75	3.76	11.00	0.00	2.75	3.60	5.00	6.50	3.57	10.10
Putrescine+Ca	0.00	2.00	2.85	3.65	4.70	2.64	8.70	0.00	1.90	2.50	3.20	4.35	2.39	8.00
Salicylic acid+Ca	0.00	2.55	3.45	4.40	6.00	3.28	9.70	0.00	2.30	3.10	4.10	5.60	3.03	9.25
Amino acids +Ca	0.00	2.75	3.60	4.75	6.30	3.48	10.40	0.00	2.60	3.35	4.50	6.15	3.32	9.70
Mean	0.00	2.89	4.18	5.55	7.79	-	-	0.00	2.65	3.69	4.94	7.22	-	-
L.S.D. at 5%	Treatments (T) = 0.03 Storage period (P) = 0.03 Interaction(T)x (P) = 0.05 Market life (M) = 0.15							Treatments (T) = 0.05 Storage period (P) = 0.04 Interaction(T) x (P) = 0.07 Market life (M) = 0.10						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Table 4: Effect of pre harvest treatments on firmness (lb/in^2) of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	4.80	4.50	4.00	3.00	2.20	3.70	1.70	4.60	4.20	3.80	2.50	2.00	3.41	1.90
ASA+ CIA +Ca	6.50	6.00	5.70	5.30	5.00	5.70	4.70	6.90	6.60	6.40	6.00	5.60	7.56	5.10
Putrescine+Ca	7.70	7.00	6.70	6.30	6.00	6.74	5.60	7.90	7.60	7.30	6.80	6.40	7.20	5.90
Salicylic acid+Ca	7.40	6.80	6.31	6.10	5.83	6.49	5.40	7.60	7.30	7.00	6.50	6.00	6.88	5.70
Amino acids +Ca	6.90	6.50	6.00	5.70	5.50	6.12	5.00	7.40	7.10	6.60	6.10	5.70	6.58	5.30
Mean	6.66	6.16	5.74	5.28	4.90	-	-	6.88	6.56	6.22	5.58	5.14	-	-
L.S.D. at 5%	Treatments (T) = 0.06 Storage period (P) = 0.13 Interaction(T)x (P) = 0.24 Market life (M) =0.25							Treatments (T) = 0.04 Storage period (P) = 0.03 Interaction(T)x (P) = 0.06 Market life (M) = 0.08						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Total Soluble Solids:

Results in Table (5) show that increased levels of TSS were recorded in fruit of trees treated with amino acids+ Ca $(NO_3)_2$ followed by (ascorbic acid+ citric acid)+ Ca $(NO_3)_2$ while decreased levels of T SS was noted in fruits of trees treated with putrescine+ Ca $(NO_3)_2$ or salicylic acid+ Ca $(NO_3)_2$ at harvest day in both seasons. It is obvious that TSS increased with extending of the storage period reaching the maximum values at the end of storage period (28 days) as previously detected by Davarynejad *et al* .(2013). These results might be due to loss of dry matter through respiration and metabolic activity and the loss of moisture from fruit through transpiration. During storage and at the end of cold storage ,all treatments showed increases in content of total soluble solids, although the increases were significantly lower in fruits treated with pre harvest treatments of putrescence, salicylic acid, amino acid, and antioxidants than in control treatment. As for the interaction, holding "Canino" apricot fruits in cold storage for a period of 28 days resulted in a significant low increasing in T.S.S specially pre harvest treatments of putrescine followed by in descending order salicylic acid, amino acids then (ascorbic acid+ citric acid) all with Ca $(NO_3)_2$in both seasons. Total soluble solids showed an increase during 5 days market life period. Moreover, fruits of pre harvest treatments showed the lowest increase in T.S.S values than control. The lowest increase in the TSS during cold storage and market life by pre harvest treated fruits was probably due to that additional calcium may had slowed down respiration and metabolic activity, hence retarded the ripening process and senescence of pear (Raese and Drake, 2006)and lowered contents of TSS during cold storage of papaya fruits (Mahmud *et al*., 2008).Also, the effect of putrescine can be attributed to low levels of the ethylene production and delay in ripening process (Davarynejad *et al* .,2013)and reduced fruit soluble solids concentration (SSC) of plum (Khan and Singh, 2010), and Peach (Bal,2013).SA decreased ethylene production and delayed the ripening process (Mohammadi and Aminifard, 2013) and reduced TSS (Awad ,2013) and this led to improve storability of apricot fruits.

Table 5: Effect of pre harvest treatments on T.S.S% of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	12.09	13.90	14.86	15.93	16.64	14.68	17.95	12.00	13.25	14.70	15.65	16.40	14.40	17.20
ASA+ CIA +Ca	12.50	12.70	13.30	13.60	13.90	13.20	14.20	12.30	12.54	13.22	13.53	13.72	13.06	13.90
Putrescine+Ca	10.20	10.43	10.62	10.85	11.20	10.66	12.26	9.80	10.22	10.45	10.68	10.82	10.39	12.00
Salicylic acid+Ca	11.15	11.35	11.50	11.69	11.72	11.48	12.67	10.65	10.87	10.97	11.22	11.52	11.05	12.31
Amino acids +Ca	12.70	12.90	13.20	13.50	13.70	13.20	13.98	12.55	12.74	12.90	13.20	13.44	12.96	13.63
Mean	11.73	12.26	12.69	13.11	13.43	-	-	11.46	11.92	12.45	12.86	13.18	-	-
L.S.D. at 5%	Treatments (T) = 0.15 Storage period (P) = 0.09 Interaction(T) x (P) = 0.18 Market life (M) = 0.07							Treatments (T) = 0.20 Storage period (P) = 0.13 Interaction(T) x (P) = 0.29 Market life (M) = 0.11						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Total acidity:

Table (6) show that fruit acidity was significantly decreased as the storage period extended till the end of storage period 28 days. Similarly Davarynejad *et al*. (2013) on apricot detected a decrease in acidity of fruits during storage. Pre harvest treatments especially putrescine + calcium nitrate or salicylic acid +calcium nitrate delayed the decrease in concentrations of total acidity during cold storage. Moreover, control treatment gave the lowest value of acidity in both seasons. As for the combined effect of storage period and pre harvest treatments on total acidity, putrescine or salicylic acid, amino acids and (ascorbic acid+ citric acid) all with addition Ca $(NO_3)_2$ treatments were more effective in delayed the decreasing titratable acidity during the two seasons of study. Acidity showed a trend of decrease with 5 days market life in all treatments in both seasons. The decrease of total acidity during market life was faster in control fruits compared to treated fruits which indicated more use of organic acids and high respiration rate of untreated fruit. In the present study it seems that decrease of total acidity during cold storage and market life indicated that use of organic acids in respiratory process (Ishaq *et al*.,2009).Pre harvest treatments delayed the decrease of acidity during cold storage and market life that may be due to additional calcium reduce respiration (Raese and Drake, 2006) which led to delay in metabolic changes of organic acids (Pila *et al*., 2010) and maintain titratable acidity of fruits and this led to improve storability of apricot fruits. Similar results shown by Davarynejad *et al*. (2013) with putrescine, Mahmud *et al.(*2008) and Abdrabboh (2012*)*with calcium and El-Shazly *et al* .(2013**)**on calcium and salicylic acid as they increased fruit acidity.

Vitamin C (L- Ascorbic acid):

Results presented in Table 7 indicated that the maximum values of Vitamin C content was observed at harvest or during storage in ascorbic acid +citric acid addition to calcium nitrate treatment, followed by amino acids + Ca, putrescine + Ca and salicylic acid + Ca in descending order ,while the lowest value of vitamin C was recorded by control treatment in both seasons. Means for weekly intervals show that fruit vitamin C content was gradually decreased and significantly with the progress of storage and reached the lowest significant level at the end of storage period compared with fruits at harvest .Also, Davarynejad *et al*. (2013) on apricot fruits obtained similar results**.** Regarding vitamin C content during storage at room temperature as market life, it is clear that all treatments showed a decrease in vitamin C with market life advancement in the two seasons .Fruits of the antioxidants (ascorbic acid +citric acid) +calcium nitrate still had the highest value of ascorbic acid while that control had the least content. This study has demonstrated that the pre harvest treatments especially (ascorbic acid +citric acid) with additional calcium nitrate treatment, delayed the loss of ascorbic acid at the end of stored apricot. This may be due to increase in fruit content of antioxidants may give it a defense against oxidative stress thus keeping its vitamin C and calcium reduce physiological disorders which causing oxidation of ascorbic acid and led to maintain quality and improve post harvest life of apricot. These results are in agreement with those obtained by Ali *et al*. (2010) reported that calcium minimized the disorders of peach .Calcium maintained the loss of ascorbic acid of papaya fruits (Mahmud *et al*., 2008). Mix of ascorbic acid and citric acid increased vit C in pomegranate (Fayed, 2010). putrescine gave the highest ascorbic acid in apricot (Davarynejad *et al*., 2013). Also**,** Lu *et al.* (2011) reported that SA delayed the decline of ascorbic acid content of pineapple fruit.

Table 6: Effect of pre harvest treatments on total acidity% of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons.

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	1.000	0.962	0.891	0. 702	0.635	0.838	0.500	1.220	0.873	0.731	0.652	0.551	0.805	0.530
ASA+ CIA +Ca	1.130	1.065	1.000	0.920	0.870	0.997	0.840	1.154	1.087	1.023	0.978	0.907	1.029	0.870
Putrescine+Ca	1.231	1.196	1.115	1.069	0.989	1.120	0.950	1.263	1.256	1.193	1.185	1.094	1.198	0.970
Salicylic acid+Ca	1.173	1.112	1.050	1.000	0.960	1.059	0.920	1.198	1.178	1.092	1.068	1.007	1.086	0.940
Amino acids +Ca	1.134	1.082	1.031	0.950	0.913	1.022	0.870	1.187	1.112	1.071	1.000	0.956	1.065	0.900
Mean	1.133	1.083	1.017	0.928	0.873	-	-	1.204	1.101	1.022	0.971	0.903	-	-
L.S.D. at 5%	Treatments (T) = 0.035 Storage period (P) = 0.032 Interaction(T)x (P) = 0.050 Market life (M) = 0.050							Treatments (T) = 0.045 Storage period (P) = 0.036 Interaction(T)x (P) = 0.054 Market life (M) = 0.070						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Table 7: Effect of pre harvest treatments on Vit .C (mg/ 100 g. F.W.) of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	5.80	5.35	5.00	4.25	3.45	4.77	2.85	6.12	5.77	5.19	4.50	4.00	5.11	2.95
ASA+ CIA +Ca	8.55	8.30	8.00	7.80	7.55	8.04	7.20	8.85	8.63	8.20	7.86	7.75	8.25	7.35
Putrescine+Ca	8.25	8.00	7.70	7.35	7.10	7.68	6.40	8.44	8.33	7.85	7.53	7.42	7.91	6.70
Salicylic acid+Ca	8.10	7.75	7.35	6.90	6.86	7.39	6.20	8.30	7.96	7.63	7.33	7.20	7.68	6.65
Amino acids +Ca	7.80	7.55	7.00	6.79	6.45	7.12	6.06	8.00	7.75	7.52	7.20	6.85	7.46	6.25
Mean	7.70	7.39	7.01	6.62	6.28	-	-	7.94	7.68	7.27	6.88	6.64	-	-
L.S.D. At 5%	Treatments (T) = 0.07 Storage period (P) = 0.03 Interaction(T) x (P) = 0.12 Market life (M) = 0.16							Treatments (T) = 0.24 Storage period (P) = 0.23 Interaction(T) x (P) = 0.40 Market life (M) = 0.25						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Total sugars:

The effect of different pre harvest treatments on total soluble sugars content of stored "Canino" apricot fruits are presented in Table (8).It clearly showed that total soluble sugars increased gradually and significantly with extending of storage period as previously detected by Davarynejad *et al* . (2013) **.**However, control treatment resulted in higher and faster increase in total soluble sugars during cold storage than that occurred in fruits treated with pre harvest treatments at the two seasons of this study. The increase in sugars content of fruits could be due to ripening process that led to the transformation of some carbohydrates components as starch to sugars by the enzymatic activities(Karemera and Habimana, 2014).In this respect putrescine+ Ca, salicylic acid+ Ca , the amino acids + Ca and (ascorbic acid +citric acid)+ Ca treatments in descending order gave the lowest values of total sugars as compared with the control treatment for both investigate seasons .Moreover, the effect of interaction revealed that at the end of storage period (28 days), fruits were of the pre harvest treatments putrescine+ Ca, salicylic acid+ Ca showed the lowest values of total sugars than untreated fruits in the first and second seasons. It could be said that increasing total soluble sugars may be due to increasing hydrolysis of starch and polysaccharides to soluble sugars during cold storage. Concerning the total soluble sugars of fruits at market life for 5 days, it is evident that all pre harvest treatments decline increases in total soluble sugars, whereas, the control gave the highest content of total sugars in both seasons. This may be because high respiration of control fruit which converts stored sugars or starch into energy and advances ripening. The pre harvest treatments of putrescine, SA, amino acids , and (ascorbic acid +citric acid) additional to calcium maintained on total sugars from rapid increasing during cold storage may be related with slow respiration with Ca and high levels of antioxidant enzymes and defense mechanisms from high ripening during storage , so leading to improve storability and market life of apricot .The obtained results are in agreement with PUT applications in mango (Malik *et al* . ,2003) and application of SA (Awad,2013) in peach and Abd El-Monem *et al* .(2013) in mango as they maintained on total sugars.

Table 8: Effect of pre harvest treatments on total sugars (mg/ g. F.W.) of ‘Canino’ apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	44.20	49.07	56.41	63.72	69.57	56.60	78.63	43.30	49.76	54.99	60.94	65.79	54.95	74.52
ASA+ CIA +Ca	46.52	47.98	49.33	49.75	50.94	48.92	54.20	45.08	47.64	48.22	49.00	50.49	48.09	52.50
Putrescine+Ca	37.94	39.30	41.42	43.09	43.19	40.99	46.10	36.72	8.51	40.46	41.89	42.19	39.96	44.00
Salicylic acid+Ca	39.85	39.77	42.91	44.72	45.64	42.52	48.44	37.55	39.67	41.77	43.91	44.64	41.52	46.10
Amino acids +Ca	48.00	48.51	48.84	49.35	49.58	48.86	53.37	47.22	48.47	47.69	48.09	49.02	48.10	51.48
Mean	43.30	44.93	47.78	50.13	51.78	-	-	41.97	44.81	46.63	48.77	50.43	-	-
L.S.D. at 5%	Treatments (T) = 1.56 Storage period (P) = 1.15 Interaction(T) x (P) = 1.90 Market life (M) = 2.07							Treatments (T) = 1.49 Storage period (P) = 1.06 Interaction(T) x (P) = 1.79 Market life (M) = 2.00						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Total phenols:

Results illustrated in table (9) showed that there was significant decrease in total phenols content as the storage period prolonged. Similar result was obtained by Davarynejad *et al* . (2013)on two Iranian Apricot cultivars as the total phenols levels at the initial of the storage period were higher than the end ones just for the all treatments .Moreover, the present data reveal that the highest values of total phenols were recorded for "Canino" apricot treated with pre harvest treatments putrescine+ Ca, salicylic acid + Ca ,amino acids + Ca or (ascorbic acid at +citric acid)+ Ca in descending order compared with untreated "Canino" apricot fruits which had the lowest significant means of total phenols at the end of storage period in both seasons of study .Concerning the effect of the interaction between the tested pre harvest treatments and storage period, the lowest values for total phenols was rapidly decreased in control compared with treated fruits . During storage, decrease level of total phenols might be due to breakdown of cell structure at senescence stage (Ghasemnezhad *et al.*, 2010). It was assumed that the effect of putrescine+ Ca and salicylic acid+ Ca treatments on maintain of total phenol content can be attributed to delay in senescence process. The changes happened in total phenols after 5 days from cold storage as market life of "Canino" apricot fruits in the two seasons of study. Phenol compounds are responsible for the flavor and color of fruits *(*Jeong *et al.,* 2008*)* and act as antioxidants (Robarts *et al*., 1999). Polyphenol oxidase (PPO) activity is responsible for the browning of tissues fruits through oxidation of phenolic compounds (Zhang and Zhang, 2008).It is evident that all pre harvest treatments gave the lowest decrease in total phenols with the advancing of market life compared with the control fruits .The maximum retention in phenolic compounds can be inferred by the reduced respiration, softening and acidity loss with adding calcium to pre harvest treatments. Also calcium maintained a reduced PPO activity during storage of apricot fruits (Ali *et al*., 2013). Furthermore, pre harvest treatments especially putrescine or salicylic acid treatments decreased losses total phenols that may be due to delay oxidation of phenol substances through Polyphenol oxidase (PPO) activity and this led to improve storability of apricot fruits. These results are in harmony with those obtained by Davarynejad *et al*. (2013) on putrescine, Khademi and Ershadi(2013)on salicylic acid as they increased total phenol content .

Respiration Rate:

It can be seen from (Table 10)that there was a noticeable increased initial respiration rate values in treated and untreated fruits at harvest day due to the acquisition of the fruits of the temperature field. Meanwhile values of rate of respiration decreased in the first week of storage due to lower temperature of cold storage at0°C during the two seasons of investigation. At the end of storage time, pre harvest treatments in combination with calcium nitrate tended to have the effective role in reducing the rate of respiration of apricot fruits. Meanwhile, control fruits had the highest respiration rate specially on the 28th day as fully ripe stage of fruits .Interaction data show significant reduced respiration rate by putrescine +Ca, salicylic acid+Ca treatments at different storage periods. The slower respiration rate in treated fruits may be explained by slowing ripening through PUT and SA action. Reduced respiration retards softening and slows down various compositions,which are all changes associated with ripening (Kader,1986).Similar results have also been reported by several other researchers that calcium plays a role in reducing the respiration (Raese and Drake, 2006) and when combied to putrescine or SA or amino acids or antioxidants with cold storage. Similar results have also been reported by (Martínez-Romero *et al* ., 2002 and Bal, 2013) on PUT and (Mohamed and Mehdi, 2013 and Abd El-Monem *et al*.,2013) on SA as reduced respiration rates which result in reducing senescence rate after harvest so, this led to improve storability and marketability of apricot fruits.

Table 9: Effect of pre harvest treatments on total phenolsl (mg/ g. F.W.) of 'Canino' apricot fruits during 4weeks of storage at 0 °C and 5 days market life during two seasons

Treatments (T)	2013 Season							2014 Season						
	Storage period in week (P)							Storage period in week (P)						
	0	1	2	3	4	Mean	Market life after 5 days (M)	0	1	2	3	4	Mean	Market life after 5 days (M)
Control	0.480	0.432	0.300	0.246	0.220	0.335	0.180	0.500	0.430	0.365	0.280	0.240	0.363	0.193
ASA+ CIA +Ca	0.620	0.580	0.472	0.420	0.400	0.498	0.350	0.640	0.590	0.530	0.453	0.410	0.524	0.370
Putrescine+Ca	0.680	0.620	0.560	0.520	0.490	0.574	0.430	0.730	0.692	0.600	0.570	0.530	0.624	0.460
Salicylic acid+Ca	0.642	0.634	0.533	0.460	0.445	0.543	0.400	0.700	0.660	0.560	0.510	0.480	0.582	0.430
Amino acids +Ca	0.651	0.614	0.480	0.440	0.410	0.519	0.380	0.682	0.642	0.520	0.460	0.430	0.546	0.400
Mean	0.615	0.576	0.469	0.417	0.393	-	-	0.650	0.602	0.515	0.455	0.418	-	-
L.S.D. At 5%	Treatments (T) = 0.03 Storage period (P) = 0.03 Interaction(T) x (P) =0.05 Market life (M) = 0.07							Treatments (T) = 0.04 Storage period (P) = 0.03 Interaction(T) x (P) = 0.06 Market life (M) = 0.08						

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Table 10: Effect of pre harvest treatments on respiration rate (ml CO_2 /kg/h) of 'Canino' apricot fruits during 4weeks of storage at 0 °C during two seasons

Treatments (T)	2013 Season						2014 Season					
	Storage period in week (P)						Storage period in week (P)					
	0	1	2	3	4	Mean	0	1	2	3	4	Mean
Control	32.39	2.73	3.00	3.60	3.95	9.13	32.10	2.65	2.95	3.30	3.70	8.94
ASA+ CIA +Ca	29.51	2.33	2.41	2.46	2.52	7.84	29.33	2.07	2.15	2.19	2.24	7.59
Putrescine+Ca	25.11	1.95	2.00	2.10	2.18	6.66	24.90	1.82	1.89	1.94	1.98	6.51
Salicylic acid+Ca	27.20	2.00	2.11	2.25	2.30	7.17	27.01	1.90	1.96	2.03	2.11	7.00
Amino acids +Ca	29.00	2.21	2.34	2.41	2.45	7.68	27.00	2.00	2.07	2.10	2.15	7.06
Mean	28.64	2.24	2.36	2.56	2.68	-	28.06	2.08	2.20	2.31	2.44	-
L.S.D. at 5%	Treatments (T) = 0.08 Storage period (P) = 0.05 Interaction(T) x (P) = 0.12						Treatments (T) = 0.06 Storage period (P) = 0.04 Interaction(T) x (P) = 0.09					

ASA = Ascorbic acid CIA= Citric acid Ca= Calcium nitrate

Conclusion

The overall results showed that pre-harvest treatments putrescine , salicylic acid, amino acids, and (ascorbic acid at +citric acid) combined with calcium nitrate had increased fruit weight, the yield and maintained quality parameters as reduced fruit decay and compositional changes by delaying physical and chemical changes, slowing down respiration rate during storage and market life. Pre-harvest treatments suggested being a good recommendation for keeping fruit quality as well as extending postharvest life of "Canino" apricot fruits.

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