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SOME SAFE METHODS ON KEEPING QUALITY OF APRICOT AND ITS EFFECT ON RESPIRATION RATE DURING COLD STORAGE.

BY

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ABSTRACT

The present investigation was carried out on mature "El-Amaar" apricot fruits for two successive seasons 2007-2008. Fruits were post harvest treated by dipping in $Cacl_2$ 4% or exposure to hot air that was either humid or dry. They were then stored at 0°c and RH (90-95%) for 28 days. Fruit weight loss and decay percentages, respiration rate, invertase enzyme activity and basic fruit characters were assessed weekly and at the end of storage exposure to room temperature for 3 days. Results showed that the present results reveal a pronounced clear effect of conducted treatments in maintaining fruit quality of "El-Amaar" apricot fruits during cold storage in terms of decreasing fruit weight, decay percentages, respiration rate and slowing the deterioration of the basic physical and chemical properties. The humid hot air treatment effect was very evident, conducted treatments followed by dipping in $Cacl_2$ which led to decreasing the invertase enzyme activity and thus decreasing substrates to share in Cribs cycle and thereby reducing deterioration.

Finally, it could be concluded that conducted treatments with emphasis on both hot humid air treatment and calcium chloride treatment resulted in decreasing respiration rate basically due to decreasing substrates (monosaccharide) as result of decreasing invertase enzyme activity. This decrease in the respiration rate was reflected evidently on maintaining fruit quality during and after cold storage

INTRODUCTION

Apricots are the most desirable stone fruits in Egypt. It ranks the second after peach of a total acreage of 17600 feddans producing about 105500 tons (Ministry of Agriculture Statistics, 2005). Apricots marketing period is very limited as they are climacteric fruits that deteriorate due to quick softening (Lichou 1999). Thus cold storage is highly required to delay this quick deterioration. Dipping in calcium chloride was found to be effective in prolonging cold storage period of "EL-Amaar" apricots (Ibrahim, 2005). It resulted in delay of decreasing the flesh firmness, fruit weight loss and decay percentages and maintaining the basic physical and chemical characteristics (Souty *et al.*, 1995, Ibrahim, 2005). This might be due to decreasing the respiration rate and ethylene production (Souty *et al.*, 1995), or inducing better membrane integrity during cold storage (Barreiro *et al.*, 2003). Both dry and moist hot air exposures are new safe methods used to maintain fruit quality during cold storage. Their basic action is attributed primarily to decreasing enzyme activities (YingQiang *et al.*, 2007), delaying the activity of invertase enzyme that hydrolysis sucrose to glucose and fructose (lune, 1998) that are used as substrates in Crib's cycle leading to increasing the respiration rate and thus enhancing deterioration. The effect of hot moist air is inhibiting ethylene production and thus decreasing softening rate. In addition this treatment was found to decrease soluble pectins in cell wall of apples due to polyuronide degradation. Titratable acidity declined while soluble solids were unaffected by this treatment (Lune, 1998) of less draw back as the

moisture decreasing negative effects of high temperature. The scope of the present investigation is to test the effect of three safe post harvest treatments on diminishing the respiretion activity during cold storage and thus main-taing fruit quality of "El Amaar" apricots. Effects on decreasing the activity of invertase enzyme were also assessed. Marketability of fruits after the end of cold storage was also studied by exposure of fruits 3 days at room temperature.

MATERIALS AND METHOD

This investigation was carried out during the two seasons 2007 and 2008 on "El-Amaar" apricot fruits obtained from a private orchard in kalubia Governorate. In the morning, apricot fruits of the cultivar. "El-Amaar" were picked at maturity stage when half of the surface had attained a particular yellowish – green hue (Sumnu and Bayindirl, 1995), and transported to the laboratory directly, All fruits were washed thoroughly and left to dry by Fans. Fruits were divided into groups and were subjected to the following treatments.

1- Control (untreated) washed and left to dry
2- Calcium chloride ($CaCl_2$) 4% was applied by dipping the fruits for three minutes.
3- Hot air (H. air) 45°C was exposed for three minutes.
4- Hot humid air (H.H. air) 45°C was exposed for three minutes.

All treated fruits were packed in carton boxes and stored at 0°C, 85-95% relative humidity (RH) for 28 days. Samples were taken from three replicates for each treatment and examined every 7 days intervals.

The following properties were estimated.

Fruit physical analysis:

1-**Weight loss percentage:** Fruits were periodically weighed and the percentage of weight loss was calculated by the difference between the initial weight and that recorded at the date of sampling.
2- **Decay percentage**: Was determined for each treatment according to McCormack and Brown (1973)
3- **Fruits texture:** texture was determined by using a modern texture analyzer instrument by penetrating cylinder 5 mm diameter to constant distance with a constant speed 1 mm/Second. The results were expressed as a resistance force of the skin or flesh (gm/ Cm^2).
4- **Fruits color:** It was quantified as a double stimulus colorimetrical data (L* and b* values) using a hunter colorimeter type (DP 9000). Color was represented by L* (lightness) ranges from black = **0** to white = **100** darkness, **b*** value (blue – yellow) scale readings **(McGuire, 1992).**
5- **Respiration rate:** (Co_2 production) was determined according to **Croos method (1966)** as mg Co_2/Kg/hr.

Respiration rate as mg Co_2/Kg/hr =

$$\frac{((-\%*10)\text{ free space volume of container in liters})}{(\text{Product fruit in Kg})\ (\text{Time container in closed in hours})}$$

Fruit chemical analysis:

1- **Total soluble solids percentage:** Abbe refractometer was used to determine the percentage of total soluble solids in fruit juice (A.O.A.C., 1990)
2- **Titratable acidity percentage**: It was determined as malic acid and calculated as percentage according to (A.O.A.C., 1990).
3- **Activity of invertase**: It was calculated as the amount of reducing sugars according to (Malik, C.P. and Singh, M.B., 1980)

Shelf life after cold storage:

At the end of the storage period, three replicates from each treatment were left at ambient temperature for a period of three days. Changes in the physical and chemical characteristics of the fruits were recorded, i.e. decay percentage, weight loss percentage, texture, fruits color, total soluble solids percentage and titratable acidity percentage.

Complete randomized design was used in this study. Each treatment was replicated three times data were tabulated and parameters except some chemical analysis were subjected to statistical analysis according to Snedecor and Cochran (1980). Means were compared by LSD test at 5% level.

RESULTS AND DISCUSSION

Fruit Characteristics after various periods of storage

Weight loss percentage

Table (1) indicated that fruit weight loss percentage increased significantly by the time elapsed to reach its' maximum after 4 weeks of cold storage (14.29 &10.31%) for both seasons respectively. As for the average treatment effect, it was evident that all the conducted treatments significantly reduced this parameter compared with control. Least weight loss percentage was attributed to the hot humid air treatment amounting to 3.3 & 2.96 % for both seasons respectively. On the last sampling date weight loss percentage attained by the hot humid air treatment was significantly the least (7.66 & 6.74% for both seasons respectively) compared with control and other treatments.

Decay percentage:

Data shown in Table (2) cleared that fruit started to decay slightly after 3 weeks of cold storage. Decay percentage increased significantly on the forth week to reach 0.97 & 0.90% for both seasons respectively. As for the average treatment effect, all treatments reduced the decay percentage compared with control. It is worth mentioning that decay did not appear on fruits treated with calcium chloride or with hot humid air. As for the interaction, it is evident that control fruits started to decay on the third week of storage amounting to 1.63 & 1.46% for both seasons and this percentage increased significantly on the last sampling date (3.53 & 2.96 %). Of all treated fruits, decay appeared only on hot air treated fruits on the forth sampling date amounting to 0.33 & 0.63 % for both seasons respectively. This percentage was statistically lower than control.

Fruit texture gm/Cm^2

Table (3) indicated that on the average fruit firmness decreased throughout the course of the storage period. This decrease was sharper starting from the third week of cold storage. It reached 5.46 & 5.18 gm/cm^2 after 4 weeks of cold storage in both seasons respectively. On the average, both calcium chloride and humid hot air treated fruits attained firmness that was significantly higher than both control and hot air treated fruits. As for the interaction, on the last sampling date it was evident that treated fruits attained significantly higher firmness compared with control. Differences between treatments were statistically equal.

Fruit Coloration:

Fruit coloration as affected was measured by Hunter Lab in terms of parameters (L*& b*). From the results in Table (4) Parameter L* increased gradually till the third week of cold storage after which it decreased after the forth week to reach 44.28 and 44.88 in both seasons respectively. On the average treatments had insignificant effects on this parameter. As for the interaction effect data show that on the last sampling datae treatments and control were insignificantly different in this parameter.

Data in Table (5) presented that Parameter b* increased significantly during the course of storage to reach 38.35 and 39.55 in both seasons respectively. As for the average treatment effect insignificant effects were evident. The interaction between the storage period and treatment show that on the last sampling datae, highest b values were attained by control amounting to 43.47 and 44.22 in both seasons indicating more yellow fruits compared with all treatments. Whereas; lowest values were attained by calcium chloride treated fruits.

Respiration rates:

Average respiration rate in the two seasons of the investigation as affected by storage period and conducted treatments is presented in Figure (1). Respiration rate increased gradually with the increase of the storage period. All of the conducted treatments decreased this rate compared with control. Highest decrease was attributed to the hot humid air treatment.

Total Soluble Solids Percentage (T.S.S. %):

Data in Table (6) presented that T.S.S. % increased gradually throughout the course

of the investigation. It reached significantly the highest percentage on the last sampling date (13.34 & 13.32 %) for both seasons respectively. On the average all the conducted treatments significantly decreased this parameter compared with control with insignificant differences between them. As for the interaction effect, on the last sampling date, it was clear that all the treatments resulted in fruit with a T.S.S. % that was lower than the control. The decreasing effect of the humid hot air treatment was the only one that was statistically equal (13.29 & 13.30 %) for both seasons respectively.

Titratable Acidity Percentage (TA%):

Presented data in Table (7) indicate that titratable acidity percentage decreased significantly throughout the storage period to reach 1.31% & 1.72% in both seasons respectively. As for the treatment effect, all treatments reduced TA% markedly as compared with control except for the humid hot air treatment which increased this parameter significantly in the first season. Interaction results point out, that on the last sampling data TA% was the highest in humid hot air treated fruits amounting to 1.57 & 1.27% in both seasons respectively. Other treatments were statistically equal to control.

Table (1): Effect of post harvest treatments on weight loss % of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007 & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	**0.00**
1	3.61	2.74	2.69	2.02	**2.76**	2.88	2.17	2.59	1.73	**2.34**
2	4.92	3.73	4.04	2.58	**3.82**	4.00	3.17	3.77	2.60	**3.38**
3	10.44	7.52	8.50	4.23	**7.67**	9.00	6.80	8.29	3.72	**6.95**
4	23.61	12.75	13.13	7.66	**14.29**	13.20	9.62	11.69	6.74	**10.31**
Means	**8.51**	**5.35**	**5.67**	**3.30**	**5.71**	**5.82**	**4.35**	**5.27**	**2.96**	**4.60**
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			0.81	0.9	1.8	Value		0.54	0.6	1.18

Table (2): Effect of post harvest treatments on decay % of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007- & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	**0.00**
1	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	**0.00**
2	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	**0.00**
3	1.63	0.00	0.00	0.00	**0.41**	1.46	0.00	0.33	0.00	**0.45**
4	3.53	0.00	0.33	0.00	**0.97**	2.96	0.00	0.63	0.00	**0.90**
Means	**1.03**	**0.00**	**0.07**	**0.00**	**0.28**	**0.88**	**0.00**	**0.19**	**0.00**	**0.27**
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			0.14	0.16	0.32	Value		0.15	0.175	0.346

Table (3): Effect of post harvest treatments on texture ($mg/Cm^{2)}$ of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007- & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	25.17	25.17	25.17	25.17	25.17	23.98	23.98	23.98	23.98	23.98
1	19.38	25.05	24.87	24.17	23.37	19.71	24.33	21.50	22.98	22.13
2	18.40	21.48	22.67	19.38	20.48	17.87	23.17	20.90	19.71	20.41
3	16.25	20.38	19.38	18.50	18.63	17.65	19.71	19.71	16.92	18.50
4	15.95	19.38	14.83	16.55	16.68	15.20	18.93	13.68	16.85	16.17
Means	19.03	22.29	21.38	20.75	20.87	18.88	22.03	19.96	20.09	20.24
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			1.5	1.68	3.36	Value		2.71	3.03	6.07

Table (4): Effect of post harvest treatments on Skin Lightness (L* value) of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007 & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	36.34	36.34	36.34	36.34	36.34	36.67	37.15	36.86	37.37	37.01
1	37.53	42.17	35.32	34.32	37.34	38.87	43.15	36.85	45.63	41.12
2	40.30	44.04	40.46	38.47	40.82	40.89	44.27	40.87	39.00	41.26
3	47.88	44.04	46.20	47.33	46.37	49.89	45.80	47.19	48.03	47.73
4	47.44	41.61	42.77	45.30	44.28	47.45	42.49	43.51	46.07	44.88
Means	41.90	41.64	40.22	40.35	41.03	42.75	42.57	41.06	43.22	42.40
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			2.21	2.37	4.74	Value		3.19	3.57	7.14

Table (5): Effect of post harvest treatments on (b* value) of Apricot fruits "Amaar" during cold storage at 0°Cfor seasons 2007 & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	19.72	19.72	19.72	19.72	19.72	21.23	21.23	21.23	21.23	21.23
1	19.77	24.17	22.79	21.56	22.07	21.25	25.21	23.41	22.75	23.16
2	22.66	25.24	23.72	24.06	23.92	23.24	26.75	24.94	25.30	25.06
3	38.13	36.60	36.73	34.84	36.58	38.57	37.53	38.02	38.20	38.08
4	43.47	34.26	38.19	37.47	38.35	44.22	35.41	39.79	38.75	39.55
Means	28.75	28.00	28.23	27.53	28.13	29.70	29.23	29.48	29.25	29.41
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			1.38	1.54	3.08	Value		1.375	1.539	3.078

Table (6): Effect of post harvest treatments on T.S.S% of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007 & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	11.73	11.73	11.73	11.73	11.73	11.73	11.73	11.73	11.73	11.73
1	13.03	13.13	13.53	12.67	13.09	13.10	13.20	13.60	13.10	13.25
2	13.80	13.27	13.53	13.50	13.53	13.40	13.30	13.60	13.43	13.43
3	14.17	13.90	13.67	14.00	13.93	14.27	13.73	13.80	13.87	13.92
4	14.80	14.37	13.90	14.53	14.40	14.63	14.20	13.90	14.37	14.28
Means	13.51	13.28	13.27	13.29	13.34	13.43	13.23	13.33	13.30	13.32
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			0.17	0.19	0.38	Value		0.134	0.15	0.3

Table (7): Effect of post harvest treatments on titratable acidity % of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007 & 2008.

Treatments	Control	$Cacl_2$	H. air	H.H. air	M	Control	$Cacl_2$	H. air	H.H. air	M
St. period (weeks)	First season					Second season				
0	2.20	2.20	2.20	2.20	2.20	2.37	2.37	2.37	2.37	2.37
1	1.90	1.83	1.83	2.07	1.91	2.20	1.93	1.93	1.83	1.98
2	1.63	1.63	1.57	1.90	1.68	1.90	1.73	1.50	1.67	1.70
3	1.53	1.33	1.37	1.60	1.46	1.53	1.20	1.40	1.43	1.39
4	1.27	1.20	1.20	1.57	1.31	1.13	1.17	1.13	1.27	1.18
Means	1.71	1.64	1.63	1.87	1.71	1.83	1.68	1.67	1.71	1.72
L S D at 5% Values						L S D at 5% Values				
Factor			A	B	a x b	Factor		A	B	a x b
Value			0.07	0.08	0.16	Value		0.07	0.078	0.156

Invertase enzyme activity:

The percentage of monosaccharides was taken as criteria of this enzyme activity. Data presented in Figure (2) show that as an average of both seasons, the enzyme activity decreased by increasing the storage period to reach minimal values after 21 days of storage. As a general trend all treatments decreased this activity compared with control. Both dry and humid hot air treatments had more evident effects basically after 7 and 14 days of cold storage.

Marketability after cold storage:

basic physical and chemical characteristics were taken as a criteria for marketable status after cold storage period for treated and untreated fruits after three days on room temperature Table (8). Weight loss and decay percentages were the highest in control fruits whereas it was the least with calcium chloride treated fruits followed by the hot humid air treated fruits. As for the texture, it was the highest in calcium chloride treated fruits followed by the humid hot air treated fruits compared with control and hot air treated fruits. As for the luster (L*) and yellow color parameter (b*) it was highest in hot humid air treated fruits followed by calcium chloride treated fruits. TSS % was highest in control and lowest in calcium chloride followed by humid hot air treated fruits. TA% was the least in control and highest in calcium chloride treated fruits followed by humid hot air treated fruits.

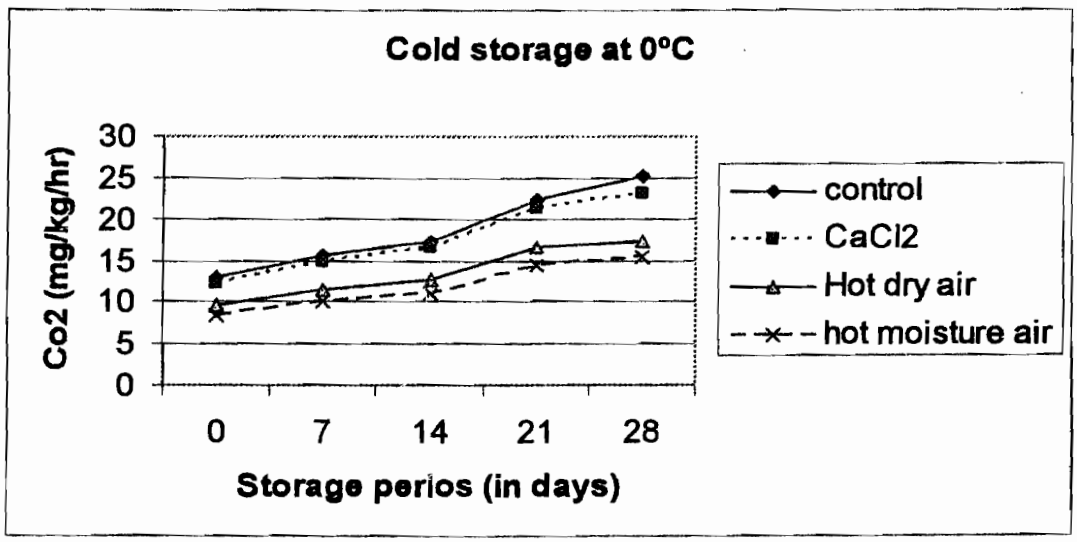

Fig. (1): Effect of post harvest treatments on respiration rates (mg Co_2/Kg/hr) of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007 & 2008.

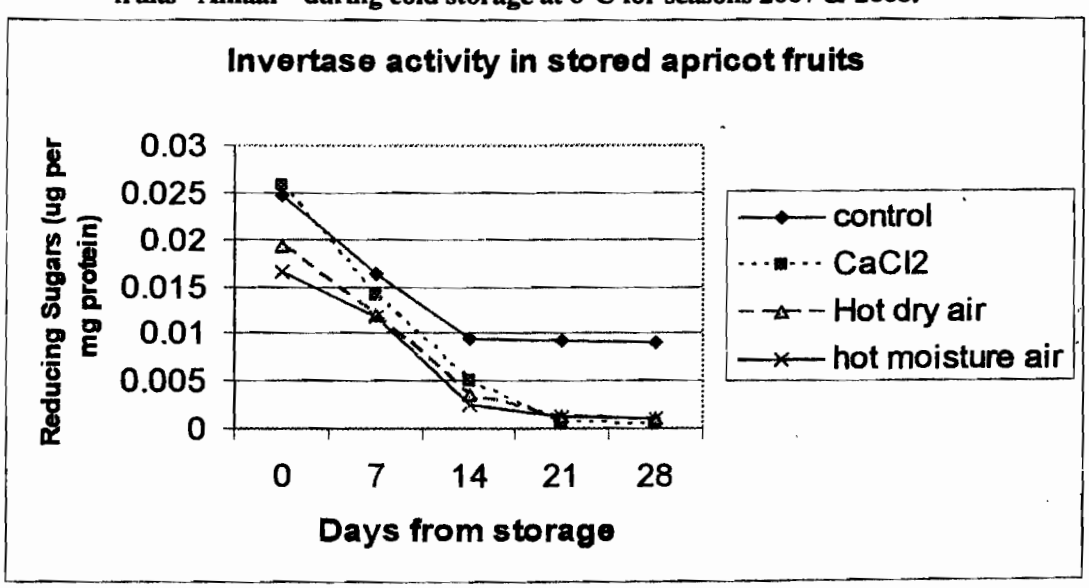

Fig. (2): Effect of post harvest treatments on Invertase enzyme activity (Reducing Sugars (µg per mg protein) of Apricot fruits "Amaar" during cold storage at 0°C for seasons 2007 & 2008.

The present results reveal a pronounced clear effect of conducted treatments in maintaining fruit quality of "El-Amaar" apricot fruits during cold storage in terms of decreasing both fruit weight and decay percentages, decreasing the respiration rate and slowing the deterioration of the basic physical and chemical properties. The humid hot air treatment effect was very evident. Conducted treatments led to decreasing the invertase enzyme activity and thus decreasing substrates to share in Cribs cycle and thereby reducing deterioration. Dipping in calcium chloride followed.

Numerous workers pointed out the beneficial effects of calcium chloride- (Souty *et al.*, 1995 and Ibrahim, 2005) on apricots. It was suggested by (Souty *et al.*, 1995) that this might be due to decreasing the respiration rate and ethylene production or inducing better membrane integrity during cold storage (Barreiro *et al.*, 2003). The technique of exposure to hot air as an effective post harvest treatment was proposed by (YoungSeo, 2003) on kiwifruit, (YiZe *et al.*, 2006) on apples (YingQiang 2007)on (Lijujube and Lune, 1998). They stated that its' effects was basically on delaying softness, decreasing decay

and titratable acidity decline during cold storage. It has been physiologically verified due to decreasing enzyme activities (Ying Qiang *et al.*, 2007), delaying the activity of invertase enzyme that hydrolysis sucrose to glucose and fructose (lune, 1998) that are used as substrates in Crib's cycle leading to increasing the respiration rate and thus enhan-cing deterioration. The effect of hot moist air is also in inhibiting ethylene production and thus decreasing softening rate. In addition this treatment was found to decrease soluble pectin's in cell wall of apples due to polyronide degradation. (Lune, 1998). The humid hot air treatment was proposed to diminish draw backs of dry air.

Finally, it could be concluded that conducted treatments with emphasis on both hot humid air treatment and calcium chloride treatment resulted in decreasing respiration rate basically due to decreasing substrates (monosaccharide) as result of decreasing invertase enzyme activity. This decrease in the respiration rate was reflected evidently on maintaining fruit quality during and after cold storage

Table (8): Effect of post harvest treatments on Apricot "Amaar" fruits shelf life after 3 days on room temperature at the end of cold storage for seasons 2007 & 2008.

Treatment	Decay %	Weight loss %	Texture mg/Cm^2	Color		T.S.S. %	Acidity %
				L*	b*		
1st Season							
Control	20.22	4.90	12.80	34.25	25.28	14.12	1.05
$CaCl_2$	5.61	2.10	22.70	42.15	30.35	12.33	1.70
H. air	15.00	3.50	15.50	37.32	22.33	13.55	1.11
H.H. air	6.00	2.30	22.50	41.92	30.63	12.56	1.65
2nd Season							
Control	19.83	5.30	13.52	35.21	22.54	13.52	0.95
$CaCl_2$	4.56	2.25	25.00	40.91	27.35	11.25	1.35
H. air	15.30	2.98	17.32	35.95	20.85	11.82	1.20
H.H. air	5.22	2.32	24.00	40.10	30.10	12.00	1.33

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بعض الطرق الأمنة في المحافظة علي جودة ثمار المشمش وعلاقتها بالتنفس أثناء التخزين المبرد

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أجريت هذه الدراسة علي ثمار المشمش "العمار" مكتملة النمو خلال موسمي ٢٠٠٧-٢٠٠٨ علي التوالي. وقد عوملت الثمار بعد الجمع بالغمس في محلول كلوريد الكالسيوم ٤% أو التعريض لهواء ساخن جاف أو رطب ثم بعد ذلك تم التخزين للثمار علي درجة الصفر المئوي ورطوبة نسبية ٩٠-٩٥% لمدة ٢٨ يوم الفقد في الوزن والنسبة المئوية للتالف ومعدل التنفس ومعدل نشاط انزيم الأنفرتيز بخلاف القياسات الطبيعية والكيميائية الأخري للثمار كانت تؤخذ اسبوعيا طوال فترة التخزين. تم وضع الثمار علي درجة حرارة الغرفة لمدة ٣ ايام بعد انتهاء فترة التخزين. وجد أن جميع المعاملات كان لها تاثير ايجابي علي جودة الثمار أثناء التخزين المبرد وذلك بتقليل معدل الفقد في الوزن ونسبة التالف كذلك تقليل معدل التنفس في الثمار مما ينعكس علي تقليل جميع العمليات الحيوية داخل الثمار. يمكن ان نستنتج من ذلك ان معاملة الهواء الساخن الرطب هي الأفضل نتيجة لتقليل نشاط أنزيم الأنفرتيز وما يترتب علية من تقليل المواد المشاركة في دورة التنفس وكانت معاملة الغمس في محلول كلوريد الكالسيوم هي التالية في المحافظة علي جودة الثمار. وفي النهاية فأن كلا من معاملة الهواء الساخن الرطب وكلوريد الكالسيوم أدي الي تقليل معدل التنفس كنتيجة لتقليل نشاط انزيم الأنفرتيز وبالتالي تقليل معدل السكريات الأحادية وهذا الإنخفاض في معدل التنفس انعكس بالإيجاب علي جودة الثمار أثناء التخزين المبرد.