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ADDITIVE EFFECTS OF PACLOBUTRAZOL PREHARVEST SPRAY AND SOME POSTHARVEST DIP TREATMENTS ON KEEPING QUALITY AND STORABILITY OF "ANNA" APPLE FRUITS

El-Helaly, Amira A.E.[1]; Mervat A.E. El Shemy[2] and M.E. Sobieh[3]
1- Hort. Res. Station Sabahia Alex., Hort.Res.Ins., A.R.C.Giza, Egypt.
2- Hort. Res. Station Sakha Kafr El-Sheikh, Hort.Res.Ins., A.R.C.Giza, Egypt.
3- Hort. Res. Institute, A.R.C.Giza, Egypt.

ABSTRACT

This experiment was performed during 2003 and 2004 seasons. "Anna" apple trees were sprayed with Paclobutrazol (PB) 250 ppm or 500 ppm, 40 or 80 days after full bloom (FB), control ones were untreated. Mature fruits of each experimental trees, were picked and subjected to the following postharvest dip treatments for 4 minutes: 3% $CaCl_2$ solution either under 350 mbar vacuum (Vac.) or not; hot water at 40°C (H.W) or tap water (as a control for dip treatments). Thereafter, fruits were stored at 3°C and 85-90% RH for 75 days. The results indicated that, in both seasons, as the storage period advanced, fruit shelf life period and V.C, malic acid contents and non reducing sugars and mineral elements % (N, P, K and Mg), significantly decreased, while the percentages of weight loss, disorders, reducing and total sugars, significantly increased. Neither PB preharvest spray, nor postharvest dip treatments, each alone influenced the storability of "Anna" fruits as same as the combination of two together. Combination treatments had a great effect on decreasing fruit weight loss and disorders %, beside increasing shelf life period and malic acid, reducing and total sugars content. However, that effect was not clearly noticed on V.C, non reducing sugars and mineral elements contents. Moreover, the fruit disorders were appeared for first time at 30 days of storage in fruits treated with postharvest dip treatments alone or those from untreated trees, while they did not notice even at 45 days of storage in fruits treated with PB 250 ppm (at both application times) + any one of postharvest dip treatments. The rest treatments showed fruit disorders at 45 days of cold storage.

$CaCl_2$ postharvest dip treatments especially under vacuum, were more effective on improving storability, than hot water treatment, when combined with PB preharvest spray treatments. Generally, all PB treatments (when were used alone) almost had the same effect on improving storability of "Anna" fruits. Despite, the earlier application (FB+40days) was more effective on reducing fruit disorders %.

Keywords: "Anna" apple fruits, paclobutrazol, $CaCl_2$, hot water and storability.

INTRODUCTION

Anna apple is the commercial cultivar planted in Egypt. This variety has many advantages such as low chilling requirements, early bearing and a high yield of good quality as compared with the local apple varieties.

Regulation of growth and cropping of apple tress is becoming increasingly important as plantings are being established at high densities, (Forshey, 1982). Paclobutrazol (PB) is a growth retardant that has shown promise for controling the growth of apple trees, (Quinlan, 1981; Miller, 1982; Steffens *et al.* 1983; Williams, 1983; Williams and Edgerton, 1983; Quinlan and Richardson, 1984 and Sterrett, 1985). PB not only controls growth, but it

may also influence cropping, (Greene and Murray, 1983; Williams, 1983 and Williams and Edgerton, 1983). Susan *et al.* (1997) reported that because of the very strong inhibitory effect on shoot growth in fruit trees, PB may enhance crop yield by reducing competition from vegetative growth.

Fruits characteristics were also influenced, (Curry and Williams, 1983; Greene and Murray, 1983 and Williams, 1983). A postbloom foliar application of PB retarded ripening and reduced senescent breakdown of "Delicious" apple, (Duane, 1986). Elfving *et al.* (1987) found that, after 24weeks of air storage, treated fruits (with preharvest PB treatment) were firmer and displayed less core browning than those untreated. Inaddition, Elfving *et al.* (1990) reported that foliar PB reduced poststorage ethylene production, (in one season).

Calcium is an important determinant factor of apple fruit quality, (Martin *et al.*, 1975). Vacuum infiltration of a $CaCl_2$ solution doubled the calcium content of fruits compared with a dip treatment in the same solution, (Conway and Sams, 1983), besides, improved maintaining fruit firmness during cold storage and the vacuum infiltration was more effective (Poovaiah, 1986). The use of calcium dipping increased fruit firmness and reduced the rate of respiration in "Anna" apples, (Attia, 1986). Dipping "Anna" apple fruits in $CaCl_2$ with or without vacuum was more effective on maintaining firmnes and reducing respiration rate, comparing with spraying preharvest $CaCl_2$ treatments, (EL-Ansary *et al.*, 1992).

With the present change in emphasis on the use of chemical treatments, interest in heat disinfection has been revided. One of the most important effects of postharvest heat treatment on apples is reduction of softening, (Klein *et al.*, 1990; Lurie and Klein 1992; Sams *et al.*, 1993; Klein and Lurie, 1994 and Mignani and Zocchi, 1994). Inaddition, respiration rate was depressed following the heat treatment of apple fruits, (Klein, 1989; Klein and Lurie 1990 and Lurie and Klein, 1990). Moreover, William *et al.* (1994) reported that prestorage heat treatment of apples has been shown to affect fruit quality during storage beneficially.

Few studies have been done on determining the additive effects of paclobutrazol preharvest spray and postharvest dipping treatments ($CaCl_2$ with or without vacuum and heat treatment through hot water), on storability of "Anna" apple fruits. Therefore, this research was carried out, to study the effect of all above mentioned treatments each alone or in combination with others on keeping quality and improving storability of "Anna" apple fruits during cold storage.

MATERIALS AND METHODS

The present study was carried out during the two successive seasons 2003 and 2004 on "Anna" apple trees. The orchard is located in El-Atwa El-Baharia, Gharbia Governorate. The trees were seven years old, planted at 5 x 5 meters apart and grafted on MM 106 rootstock. Trees used in this work were selected to be healthy and as uniform as possible in both

vegetative growth and fruit load. Cultural practices, as recommended by the ministry of agriculture for apples.

Forty of the selected trees were used for this work. Each of the following treatments were carried out on 4 replicates/ treatment. Each replicate was represented by two trees. The preharvest treatments were as follows.

1. Control: Trees were untreated.
- Paclobutrazol (PB): [(2RS, 3RS)-1-(4- chlorophenyl-4-4-dimethyl-2-(1H-1,2,4-triazol-lyl) pentan-3-oL] was sprayed at.
2. 250 ppm, 40 days after full bloom (FB+40 days).
3. 500 ppm, 40 days after full bloom (FB+40 days).
4. 250 ppm, 80 days after full bloom (FB+80 days).
5. 500 ppm, 80 days after full bloom (FB+80 days).

Mature fruits were picked, from the trees subjected to above mentioned treatments, 103 days after petal fall. Defective fruits as injured misshapen or off size fruits were discarded and only sound fruits were used for the following postharvest treatments.

1. Dipping the fruits, for 4 minutes, in tap water (control).
2. Dipping the fruits, for 4 minutes, in 3% $CaCl_2$ solution.
3. Dipping the fruits, for 4 minutes, in 3% $CaCl_2$ solution under 350 mbar vacuum.
4. Dipping the fruits, for 4 minutes, in hot water (40°C).

The fruits were then dried by the aid of electric fans, before packing in carton boxes. Fruits of each treatment were represented by three replicates (cartons, each consisted of 20 fruits), for every sampling date. On that basis, the total number of cartons was: 20 treatments (5 preharvest x 4 postharvest) x 3 replicates (cartons) x 5 sampling dates = 300 cartons. All cartons (contained 20 fruits each) were stored in a commercial refrigerator at Kafr El-Zayat, Gharbia Governorate, at 3°C with relative humidity of 85-90%. Three cartons of each treatment was taken out after 0,30,45, 60 and 75 days of storage to determine the following physical and chemical properties

1. Weight loss: as a percentage from the initial weight.
2. Disorders: the number of fruits affected with either pathological or physiological disorders was calculated as percentage from the total number of each sample.
3. Shelf-life: A sample of 10 fruits of each replicate was taken out of storage, at each exstorage date and left at room temperature (23-25°C). when 50% of fruits were unmarketable, the experiment was terminated and the number of days was calculated and considered as shelf-life.
4. Ascorbic acid (VC): was determined in filtered juice samples and expressed as mg/100 ml juice as described by A.O.A.C. (1985).
5. Titratable acidity (TA): was determined as gm malic acid/100 gm fresh weight A.O.A.C. (1985).
6. Mineral element contents: nitrogen, phosphorus, potassium and magnesium were determined using atomic absorption spectro-photometer A.O.A.C. (1985).

7. Sugars: total sugars were determined colorimetrically using phenol and sulphuric acid according to Malik and Singh (1980). Reducing sugars were determined by the Nelson arsenate-molybdate coloremetric method (Dubois *et al.* 1956). Then non reducing sugars were calculated by the difference between total and reducing sugars.

The data throughout the course of this study were statistically analyzed (three factors experiment in randomized complete block design)according to Little and Hills (1972).

RESULTS AND DISCUSSION

1. Weight loss

The percentages of weight loss were significantly increased as the storage period advanced, (Table 1). Fruit weight loss occurred naturally mainly as a result of water loss from the fruit tissues during storage and partially during respiration process. The results were confirmed with those found on apples by Kassem (1991); pears by Schirra *et al.* (1997) and on persimmons by Aly *et al.* (2000).

As an average for all storage periods, the highest significant percentages of weight loss were found in fruits of control treatment (unsprayed trees + dip in tap water) in the first season and either $CaCl_2$ or PB 250 ppm (FB + 80 days) treatments in the second. These findings agreed with those found by Blanpied (1981) who found a significant increase in water loss of "McIntoch" apples which applied in 3% $CaCl_2$. However, Attia (1986) reported that weight loss percentages of "Anna" apple were not influenced by dipping the fruits in 3-5% $CaCl_2$ solution. On the other side, PB treatments when followed by postharvest dip treatments, weight loss percentages were reduced. As an average for all storage periods, PB 500 ppm (FB + 80 days) + H.W treatments in the first season and PB 500 ppm (FB + 40 days) + $CaCl_2$ under vacuum treatments in the second, showed the least significant percentages of weight loss compared with all other treatments, except PB 250 ppm (FB + 40 days) + $CaCl_2$ treatments (in first season) as the differences were not significant. Obtained results were in line with those found by Bulatovic and Tarailo (1981).

2. Disorders

The data illustrated in Table (2) disclosed that in both experimental seasons, as an average for all treatments, fruit disorders %, were gradually increased by increasing the storage time, moreover the differences were significant among storage periods.

The least significant percentages of fruit disorders were existed in fruits treated with PB 250 ppm (FB+40days) + $CaCl_2$ under vacuum (1.356 and 1.323% in first and second season, respectively), as on average for all storage periods. On the contrary, the highest significant ones were found in untreated ones (14.063 and 9.454 % in first and second seasons, respectively).

Table (1): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on the percentage of weight loss of "Anna" apple fruits during cold storage.

Treatments		Time (T) days									
		First season					Second season				
Dip. (D)	Spray (S)	30	45	60	75	(DXS) average	30	45	60	75	(DXS) average
Tap water	Control	1.45	1.85	2.45	3.39	2.29	0.992	2.362	2.596	3.528	2.370
	PB250 (FB+40 days)	1.19	2.17	2.23	2.34	1.98	1.225	1.995	2.663	2.698	2.145
	PB500 (FB+40 days)	1.16	1.35	1.53	2.29	1.58	1.012	1.760	2.123	2.684	1.895
	PB250 (FB+80 days)	1.23	1.25	1.57	2.25	1.57	1.717	2.045	3.464	3.572	2.700
	PB500 (FB+80 days)	1.01	1.11	1.40	1.89	1.35	1.127	1.500	2.143	2.978	1.937
$CaCl_2$-3%	Control	1.48	2.02	2.56	2.83	2.22	1.619	2.330	2.905	3.973	2.707
	PB250 (FB+40 days)	1.00	1.07	1.53	1.70	1.33	1.358	2.227	2.963	3.438	2.497
	PB500 (FB+40 days)	1.09	1.22	1.61	2.30	1.55	1.210	1.875	2.191	2.705	1.995
	PB250 (FB+80 days)	1.09	1.18	1.79	1.80	1.47	1.630	2.122	3.097	3.199	2.512
	PB500 (FB+80 days)	1.14	1.25	2.03	2.06	1.62	1.002	1.717	2.034	2.771	1.881
$CaCl_2$ 3% Vac.	Control	1.37	1.65	2.16	2.40	1.90	1.815	2.137	2.471	2.853	2.319
	PB250 (FB+40 days)	1.17	1.45	2.04	2.25	1.73	1.161	1.913	2.226	2.921	2.066
	PB500 (FB+40 days)	1.34	1.44	1.85	2.80	1.86	1.289	1.686	1.531	2.361	1.717
	PB250 (FB+80 days)	1.03	1.15	1.66	2.38	1.55	1.297	1.885	2.311	2.650	2.036
	PB500 (FB+80 days)	0.87	1.06	1.78	1.80	1.38	1.395	1.692	2.569	2.713	2.092
Hot water	Control	1.26	1.53	2.12	2.16	1.77	1.127	1.955	2.627	2.968	2.169
	PB250 (FB+40 days)	1.01	1.33	1.83	2.25	1.61	0.999	1.606	2.504	2.656	1.941
	PB500 (FB+40 days)	1.13	1.42	1.62	2.06	1.56	1.151	1.759	2.305	3.325	2.135
	PB250 (FB+80 days)	0.88	0.89	1.74	2.09	1.40	1.294	1.447	1.905	3.025	1.918
	PB500 (FB+80 days)	0.87	1.12	1.53	1.68	1.30	0.949	1.788	2.371	2.705	1.953
(T) average		1.14	1.38	1.85	2.24		1.268	1.890	2.452	2.986	

L.S.D	(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
0.05	0.020	0.044	0.088	0.045	0.100	0.200
0.01	0.026	0.058	0.116	0.059	0.132	0.264

Table (2): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on desorders (%) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days											
		First season						Second season					
Dip. (D)	Spray (S)	0	30	45	60	75	(DXS) average	0	30	45	60	75	(DXS) average
Tap water	Control	0.000	10.976	14.333	20.036	24.970	14.063	0.000	5.476	8.003	13.880	19.910	9.454
	PB250 (FB+40 days)	0.000	0.000	7.140	11.110	11.430	5.936	0.000	0.000	6.426	9.116	10.093	5.127
	PB500 (FB+40 days)	0.000	0.000	2.700	7.140	11.760	4.320	0.000	0.000	2.300	6.116	10.230	3.729
	PB250 (FB+80 days)	0.000	0.000	14.250	14.743	15.150	8.829	0.000	0.000	8.903	9.190	11.000	5.819
	PB500 (FB+80 days)	0.000	0.000	13.760	14.253	15.576	8.718	0.000	0.000	7.913	9.013	11.733	5.732
$CaCl_2$ 3%	Control	0.000	8.300	10.430	11.710	12.460	8.580	0.000	4.00	5.293	10.283	12.803	6.476
	PB250 (FB+40 days)	0.000	0.000	0.000	3.570	10.350	2.784	0.000	0.000	0.000	3.076	6.863	1.988
	PB500 (FB+40 days)	0.000	0.000	2.350	6.670	8.820	3.568	0.000	0.000	1.920	5.050	6.300	2.654
	PB250 (FB+80 days)	0.000	0.000	0.000	6.250	9.330	3.116	0.000	0.000	0.000	4.980	6.640	2.324
	PB500 (FB+80 days)	0.000	0.000	3.700	7.696	11.246	4.529	0.000	0.000	3.160	5.743	7.173	3.215
$CaCl_2$ 3% Vac.	Control	0.000	3.503	6.206	8.533	10.776	5.804	0.000	3.200	5.070	7.753	8.723	4.949
	PB250 (FB+40 days)	0.000	0.000	0.000	3.330	3.450	1.356	0.000	0.000	0.000	2.133	4.483	1.323
	PB500 (FB+40 days)	0.000	0.000	1.983	6.060	7.693	3.147	0.000	0.000	1.800	4.040	5.190	2.206
	PB250 (FB+80 days)	0.000	0.000	0.000	5.260	8.330	2.718	0.000	0.000	0.000	4.000	4.433	1.887
	PB500 (FB+80 days)	0.000	0.000	2.940	4.170	5.266	2.475	0.000	0.000	2.520	4.273	6.303	2.619
Hot water	Control	0.000	5.806	6.600	9.106	15.696	7.442	0.000	3.810	5.426	7.820	9.136	5.239
	PB250 (FB+40 days)	0.000	0.000	0.000	7.140	10.340	3.496	0.000	0.000	0.000	6.063	6.940	2.601
	PB500 (FB+40 days)	0.000	0.000	2.566	3.150	8.526	2.849	0.000	0.000	2.153	5.606	6.556	2.863
	PB250 (FB+80 days)	0.000	0.000	0.000	8.330	12.260	4.118	0.000	0.000	0.000	6.410	7.213	2.725
	PB500 (FB+80 days)	0.000	0.000	7.110	8.616	12.130	5.571	0.000	0.000	3.770	6.626	8.000	3.679
(T) average		0.000	1.429	4.804	8.344	11.278		0.000	0.824	3.233	6.559	8.536	

L.S.D		(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
	0.05	0.007	0.014	0.031	0.008	0.015	0.034
	0.01	0.009	0.018	0.041	0.010	0.020	0.045

It has generally been found that, the combination of PB preharvest spray and postharvest dip treatments was more effective on reducing fruit disorders, compared with each applied separately, as an average for all storage periods, in both experimental seasons. It was also clearly noticed that, the earlier application of PB (FB+ 40 days) especially at high concentration (500 ppm) was more effective on reducing fruit disorders than the later one (FB+80days).The effectiveness of application time was more obviously noticed when PB treatments were used alone.

The data also revealed that the best postharvest dip treatments on reducing fruit disorders % were $CaCl_2$ under vacuum followed by H.W then the last one was $CaCl_2$ (5.804,7.442 and 8.580% in first season and 4.949, 5.239 and 6.476 in second one, respectively), as an average for all storage periods, and the differences were significant among them. That arrangement was not clearly obvious when those treatments combined with PB preharvest spray treatments, except the superiority of $CaCl_2$ under vacuum treatment.

It was worth noting that, the fruit disorders were have been discovered for the first time at 30 days of storage in fruits treated with postharvest dip treatments only or untreated ones, while they didn't notice even at 45 days of storage in those treated with PB250 ppm (at both application times) + any one of postharvest dip treatments. The rest treatments showed fruit disorders at 45 days of storage.

As either PB preharvest spray or postharvest dip treatments (Ca Cl_2 with or without vacuum or H.W) appeared to have positive effects on maintaining fruit firmness and reducing respiration rates, (Attia, 1986; Elfving *et al.* 1987 and Lurie and Klein, 1990), it is perhaps not surprising that a compination of both favor their beneficial effects on reducing fruit disorders. The above mentioned data and related discussion were supported by those previously found by Duane (1986); Elving *et al.* (1987) and Duane (1991) on apples. They all reported that trees were have been treated with PB produced fruits with less bitter pit, cork spot and senescent breakdown following regular air storage. Susan *et al.* (1997) noticed that 4 weeks regular air storage at 0C° did not lead to any internal disorders in the plum fruits from trees treated with PB. In addition, the effect of $CaCl_2$ on reducing storage disorders was in line with those of Moline and Locke (1993); Sams *et al.*(1993); Hanson *et al.* (1993). Klein and Lurie (1994) and Raese and Drake (1995). Moreover Sams *et al.*(1993); Mignani and Zocchi (1994) and William *et al.* (1994) on apples and Schirra *et al.* (1997) on pears, they all reported a reducing effect on storage disorders of heated fruits.

3. Shelf life

The data introduced in Table (3) declared that fruit shelf life period decreased gradually as the storage period progressed. As an average for all storage periods, PB 250 ppm (FB + 80 days) + $CaCl_2$ and PB 500ppm (FB + 40 days) + $CaCl_2$ Vac. treatments (in both seasons) and PB 250 ppm (FB + 40 days) + $CaCl_2$ Vac. (in first season) gave the longest significant shelf life periods, comparing with other treatments. On the other side, untreated fruits (in both seasons) and those treated with $CaCl_2$ Vac. or H.W (in first one) had the shortest significant shelf life period.

Table (4): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on V-C (mg/100 ml juice) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days											
		First season						Second season					
Dip. (D)	Spray (S)	0	30	45	60	75	(DXS) average	0	30	45	60	75	(DXS) average
Tap water	Conrol	6.10	5.95	5.17	4.81	4.37	5.28	6.580	6.150	5.233	4.833	3.887	5.337
	PB250 (FB+40 days)	6.53	5.85	4.76	4.76	3.74	5.13	7.040	6.093	5.273	5.247	5.067	5.744
	PB500 (FB+40 days)	6.39	5.44	4.90	4.63	4.22	5.12	8.703	6.667	6.450	5.670	5.120	6.524
	PB250 (FB+80 days)	7.21	6.53	6.53	6.26	5.04	6.31	7.500	5.537	5.283	5.250	4.650	5.644
	PB500 (FB+80 days)	6.80	4.90	4.49	4.49	4.35	5.01	7.200	5.880	5.600	5.427	4.500	5.721
$CaCl_2$ 3%	Control	6.10	5.83	5.38	4.97	4.41	5.34	6.580	6.080	6.020	5.883	4.507	5.814
	PB250 (FB+40 days)	6.53	6.53	6.26	5.98	4.49	5.96	7.040	6.777	6.610	5.700	5.250	6.275
	PB500 (FB+40 days)	6.39	5.58	4.49	4.35	4.35	5.03	8.703	6.203	6.160	6.090	5.460	6.523
	PB250 (FB+80 days)	7.21	6.26	4.90	4.90	4.22	5.50	7.500	6.530	6.450	4.800	4.290	5.914
	PB500 (FB+80 days)	6.80	6.67	6.67	5.58	5.31	6.20	7.200	7.040	4.807	4.350	3.900	5.459
$CaCl_2$ 3% Vac.	Control	6.10	6.02	5.87	5.79	4.93	5.74	6.580	5.060	4.933	4.817	4.160	5.110
	PB250 (FB+40 days)	6.53	5.44	5.17	4.08	3.81	5.01	7.040	6.940	6.783	4.960	4.060	5.957
	PB500 (FB+40 days)	6.39	5.17	4.90	4.08	3.40	4.79	8.703	6.467	5.600	4.800	3.917	5.897
	PB250 (FB+80 days)	7.21	5.17	5.04	4.63	3.67	5.14	7.500	7.467	4.340	4.333	3.300	5.388
	PB500 (FB+80 days)	6.80	5.31	4.90	4.76	4.22	5.20	7.200	5.887	5.700	5.660	4.800	5.849
Hot water	Control	6.10	5.35	5.01	4.14	4.06	4.93	6.580	6.793	5.250	5.140	3.857	5.524
	PB250 (FB+40 days)	6.53	6.12	4.90	4.76	4.49	5.36	7.040	6.287	5.077	4.753	4.350	5.501
	PB500 (FB+40 days)	6.39	5.17	4.22	3.94	3.67	4.68	8.703	6.510	6.150	5.200	5.133	6.339
	PB250 (FB+80 days)	7.21	7.08	5.58	3.54	3.40	5.36	7.500	6.880	6.800	5.117	4.050	6.069
	PB500 (FB+80 days)	6.80	6.67	6.39	4.22	3.54	5.52	7.200	6.357	6.150	5.120	3.750	5.715
(T) average		6.61	5.85	5.28	4.73	4.18		7.405	6.380	5.734	5.158	4.400	

L.S.D	(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
0.05	0.091	0.182	0.407	0.087	0.174	0.389
0.01	0.120	0.240	0.537	0.115	0.230	0.513

Table (5): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on titratable acidity (gm malic acid/100 gm fresh weight) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days											
Dip. (D)	Spray (S)	First season						Second season					
		0	30	45	60	75	(DXS) average	0	30	45	60	75	(DXS) average
Tap water	Control	0.635	0.631	0.546	0.503	0.483	0.560	0.430	0.408	0.376	0.300	0.213	0.345
	PB250 (FB+40 days)	0.658	0.611	0.576	0.520	0.473	0.568	0.484	0.355	0.290	0.229	0.171	0.306
	PB500 (FB+40 days)	0.706	0.651	0.620	0.551	0.439	0.593	0.448	0.274	0.254	0.234	0.169	0.276
	PB250 (FB+80 days)	0.716	0.638	0.620	0.576	0.435	0.597	0.452	0.352	0.337	0.300	0.217	0.332
	PB500 (FB+80 days)	0.827	0.751	0.590	0.499	0.494	0.632	0.522	0.329	0.301	0.281	0.270	0.341
$CaCl_2$ 3%	Control	0.635	0.583	0.548	0.503	0.437	0.541	0.430	0.374	0.370	0.329	0.212	0.343
	PB250 (FB+40 days)	0.658	0.650	0.638	0.581	0.512	0.608	0.484	0.348	0.332	0.274	0.243	0.336
	PB500 (FB+40 days)	0.706	0.642	0.629	0.529	0.426	0.586	0.448	0.313	0.293	0.250	0.248	0.310
	PB250 (FB+80 days)	0.716	0.664	0.612	0.529	0.481	0.600	0.452	0.386	0.375	0.311	0.239	0.353
	PB500 (FB+80 days)	0.827	0.694	0.612	0.577	0.568	0.655	0.522	0.365	0.321	0.314	0.255	0.355
$CaCl_2$ 3% Vac.	Control	0.635	0.617	0.575	0.544	0.491	0.572	0.430	0.376	0.286	0.251	0.270	0.323
	PB250 (FB+40 days)	0.658	0.650	0.643	0.529	0.512	0.598	0.484	0.377	0.315	0.278	0.273	0.345
	PB500 (FB+40 days)	0.706	0.677	0.581	0.490	0.443	0.579	0.448	0.340	0.328	0.228	0.208	0.310
	PB250 (FB+80 days)	0.716	0.594	0.507	0.475	0.422	0.543	0.452	0.374	0.279	0.262	0.227	0.319
	PB500 (FB+80 days)	0.827	0.698	0.685	0.577	0.512	0.660	0.522	0.350	0.340	0.327	0.320	0.372
Hot water	Cont.	0.635	0.610	0.500	0.499	0.369	0.522	0.430	0.371	0.334	0.273	0.268	0.335
	PB250 (FB+40 days)	0.658	0.625	0.616	0.512	0.430	0.568	0.484	0.436	0.374	0.328	0.279	0.380
	PB500 (FB+40 days)	0.706	0.585	0.528	0.473	0.460	0.550	0.448	0.355	0.353	0.327	0.237	0.344
	PB250 (FB+80 days)	0.716	0.554	0.537	0.599	0.464	0.574	0.452	0.334	0.268	0.219	0.211	0.297
	PB500 (FB+80 days)	0.827	0.751	0.590	0.499	0.494	0.632	0.522	0.281	0.273	0.261	0.220	0.311
(T) average		0.708	0.644	0.588	0.528	0.467		0.467	0.355	0.320	0.279	0.238	

L.S.D	(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
0.05	0.008	0.016	0.036	0.004	0.007	0.016
0.01	0.011	0.021	0.048	0.005	0.010	0.022

It could be concluded that TA was increased by the combination of PB preharvest and postharvest treatments, while when PB or H.W treatment was used alone, the least significant values of TA were existed.

These findings were in line with those previously reported by Susan *et al.*, (1997). They noticed that PB had no effect on TA of "Red Rosa" plum fruits stored for 8 weeks at 0°C. On the other hand, Sharples and Johnson (1977); Drake and Spayd (1983) and Klein *et al.*, (1990) found that treating apple fruits with $CaCl_2$ increased TA during prolonged cold storage. However, Klein and Lurie (1990) found that dipping apples in 2% $CaCl_2$ solution did not affect TA, also Raese and Drake (1995) noticed that different $CaCl_2$ concentrations or time of spray application on "Anjou" pears had no effect on TA. Concerning heat treatment, Klein *et al.*, (1990) and Lurie and Klein (1992) on apples and McCollum *et al.*, (1993) on mangoes and Yee and Rose (1994) on nectarines found that heated fruits were lower in TA than untreated ones.

6. Mineral elements contents (N, P, K, and Mg)

Data of the two experimental seasons (Tables 6, 7, 8, and 9) indicated that, as an average for all treatments, fruit mineral contents (N, P, K, and Mg) significantly decreased as the storage period advanced.

In both seasons, as an average of all storage periods, fruit N content was not influenced by any of experimental treatments, as the differences were insignificant among them.

Concerning fruit P content, the highest significant percentages were found in fruits from trees treated with PB 500 ppm (FB + 80 days) + $CaCl_2$ (in first season) and PB 250 ppm (FB + 80 days) alone (in second one). Whereas the least ones were found in untreated fruits (in first season) and those treated with PB 500 ppm (FB + 80 days) either alone or in combination with $CaCl_2$ or H.W (in the second). That means, the influence of experimental treatments on fruit P content, had no definit trend.

In respect to fruit K content, the same trend was almost noticed, as the highest significnat percentages were found in fruits treated with PB 250 ppm (FB + 40 days) either alone or in combination with $CaCl_2$ under Vac. or not (in first season) and in those treated with PB 250 ppm (FB + 80 days) either with H.W or $CaCl_2$ and PB 250 ppm (FB + 40 days) with H.W or $CaCl_2$ Vac. (in second one). On the contrary the least significant ones were found in fruits from trees treated with PB 500 ppm (FB + 80 days) alone or with any one of posthervest dip treatments; PB 250 ppm (FB + 80 days) + H.W; $CaCl_2$ or untreated ones (in first season) and fruits treated with $CaCl_2$ or untreated (in second one). Generally, using PB early (FB + 40 days) at lower concentration (250 ppm) was more effective on increasing fruit K content comparing with the late application (FB+80 days) at higher concentration (500 ppm). On the other side, postharvest dip treatments almost have the same effects on fruit K content.

As for fruit Mg content, the highest significant percentages were found in fruits treated with PB 500 ppm (FB + 40 days) (in first season) and PB 250 ppm (at the same time) + $CaCl_2$ (in second one). The least significant values were existed in untreated fruits. These findings were in harmony with those found by Nardin and Brienza (1983) on "Glosteer 69" apples.

Table (6): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on nitrogen contetn (N%) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days					
		First season			Second season		
Dip. (D)	Spray (S)	0	75	(DXS) average	0	75	(DXS) average
Tap water	Control	0.967	0.800	0.883	1.000	0.800	0.900
	PB250 (FB+40 days)	1.200	0.800	1.000	0.933	0.800	0.867
	PB500 (FB+40 days)	1.067	1.000	1.033	1.600	1.100	1.350
	PB250 (FB+80 days)	1.100	1.067	1.083	1.100	0.900	1.000
	PB500 (FB+80 days)	0.900	0.833	0.867	1.100	0.867	0.983
$CaCl_2$ 3%	Control	0.967	0.833	0.900	1.000	0.933	0.967
	PB250 (FB+40 days)	1.200	0.867	1.033	0.933	0.867	0.900
	PB500 (FB+40 days)	1.067	0.967	1.017	1.600	0.800	1.200
	PB250 (FB+80 days)	1.100	0.800	0.950	1.100	0.900	1.000
	PB500 (FB+80 days)	0.900	0.800	0.850	1.100	0.850	0.975
$CaCl_2$ 3% Vac.	Control	0.967	0.817	0.892	1.000	0.967	0.983
	PB250 (FB+40 days)	1.200	0.900	1.050	0.933	0.867	0.900
	PB500 (FB+40 days)	1.067	1.000	1.033	1.600	1.100	1.350
	PB250 (FB+80 days)	1.100	0.933	1.017	1.100	1.100	1.100
	PB500 (FB+80 days)	0.900	0.867	0.883	1.100	0.933	1.017
Hot water	Cont.	0.967	0.883	0.925	1.000	0.967	0.983
	PB250 (FB+40 days)	1.200	0.900	1.050	0.933	0.800	0.867
	PB500 (FB+40 days)	1.067	0.900	0.983	1.600	1.133	1.367
	PB250 (FB+80 days)	1.100	1.067	1.083	1.100	0.917	1.008
	PB500 (FB+80 days)	0.900	0.700	0.800	1.100	1.100	1.100
(T) average		1.047	0.887		1.147	0.935	

L.S.D	(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
0.05	0.036	NS	NS	0.052	NS	NS
0.01	0.048			0.069		

Table (9): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on magnesium content (Mg %) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days					
Dip. (D)	Spray (S)	First season			Second season		
		0	75	(DXS) average	0	75	(DXS) average
Tap water	Control	0.294	0.246	0.270	0.305	0.250	0.278
	PB250 (FB+40 days)	0.410	0.354	0.382	0.391	0.281	0.336
	PB500 (FB+40 days)	0.407	0.462	0.434	0.358	0.282	0.320
	PB250 (FB+80 days)	0.375	0.457	0.416	0.302	0.274	0.288
	PB500 (FB+80 days)	0.448	0.252	0.350	0.410	0.308	0.359
$CaCl_2$ 3%	Control	0.294	0.269	0.282	0.305	0.270	0.288
	PB250 (FB+40 days)	0.410	0.253	0.331	0.391	0.528	0.459
	PB500 (FB+40 days)	0.407	0.434	0.420	0.358	0.250	0.304
	PB250 (FB+80 days)	0.375	0.420	0.397	0.302	0.300	0.301
	PB500 (FB+80 days)	0.448	0.357	0.402	0.410	0.285	0.347
$CaCl_2$ 3% Vac.	Control	0.294	0.281	0.288	0.305	0.281	0.293
	PB250 (FB+40 days)	0.410	0.310	0.360	0.391	0.453	0.422
	PB500 (FB+40 days)	0.407	0.236	0.321	0.358	0.318	0.338
	PB250 (FB+80 days)	0.375	0.358	0.366	0.302	0.285	0.293
	PB500 (FB+80 days)	0.448	0.286	0.367	0.410	0.290	0.350
Hot water	Cont.	0.294	0.277	0.285	0.305	0.289	0.297
	PB250 (FB+40 days)	0.410	0.318	0.364	0.391	0.299	0.345
	PB500 (FB+40 days)	0.407	0.298	0.352	0.358	0.361	0.360
	PB250 (FB+80 days)	0.375	0.359	0.367	0.302	0.369	0.336
	PB500 (FB+80 days)	0.448	0.394	0.421	0.410	0.444	0.427
(T) average		0.387	0.331		0.353	0.321	

L.S.D	(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
0.05	0.002	0.006	0.009	0.001	0.004	0.006
0.01	0.003	0.008	0.012	0.002	0.005	0.008

7. Sugars (total, reducing and non reducing)

The data demonstrated in Table (10,11,12) showed that in both seasons, as an average for all treatments, total and reducing sugars increased, whiie non reducing ones decreased as the storage period advanced, with significant differences between storage periods. These results were in agreement with those reported by numerous investigators working on different apple varieties, Olsen and Martin (1980); Subrtova *et al.*, (1987) and Kassem (1991), who found that the glucose and fructose content (reducing sugars) of the fruits increased during storage, whereas sucrose (non-reducing sugars) decreased.

The highest total and reducing sugars % were existed in fruits treated with PB 500 ppm (FB+80 days) + $CaCl_2$ Vac. (in first season) and PB 250 ppm (FB+40 days) + $CaCl_2$ under vacuum or not (in second), with significant differences over those treated with other treatments, as an average for all storage periods. While the least significant total and reducing sugars % were found in untreated fruits in both seasons and in those treated with H.W in the second one.

Regarding, non reducing sugars, the highest significant percentages were found in "Anna" fruits treated with PB 250 ppm (FB+80 days) either followed by $CaCl_2$ or not (in first season) and PB 500 ppm (FB+40 days) followed by $CaCl_2$ (in second) as an average for all storage periods. On the other side, the least significant values were existed in fruits treated with $CaCl_2$ under vacuum (in first season) and those treated with PB 250 ppm (FB+40 or 80 days) followed by $CaCl_2$ (in second season). Obtained results were in line with those found by Klein *et al.*, (1990) on "Anna" and "Granny Smith" apples and Glenn and Poovaiah (1990) on "Golden Delicious" apple fruits.

Table (10): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on total sugars (%) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days					
Dip. (D)	Spray (S)	First season			Second season		
		0	75	(DXS) average	0	75	(DXS) average
Tap water	Control	25.637	28.556	27.096	22.937	32.735	27.836
	PB250 (FB+40 days)	30.651	33.364	32.008	33.833	39.417	36.625
	PB500 (FB+40 days)	37.497	40.028	38.763	38.440	39.248	38.844
	PB250 (FB+80 days)	37.358	37.512	37.435	31.005	44.139	37.572
	PB500 (FB+80 days)	44.348	44.260	44.304	29.640	40.390	35.015
$CaCl_2$ 3%	Control	25.637	34.221	29.929	22.937	36.063	29.500
	PB250 (FB+40 days)	30.651	35.666	33.158	33.833	51.036	42.434
	PB500 (FB+40 days)	37.497	40.369	38.933	38.440	42.488	40.464
	PB250 (FB+80 days)	37.358	45.428	41.393	31.005	50.373	40.689
	PB500 (FB+80 days)	44.348	45.930	45.139	29.640	48.598	39.119
$CaCl_2$ 3% Vac.	Control	25.637	35.254	30.445	22.937	36.809	29.873
	PB250 (FB+40 days)	30.651	36.733	33.692	33.833	50.167	42.000
	PB500 (FB+40 days)	37.497	47.986	42.741	38.440	43.708	41.074
	PB250 (FB+80 days)	37.358	45.533	41.446	31.005	51.202	41.104
	PB500 (FB+80 days)	44.348	46.663	45.506	29.640	51.450	40.545
Hot water	Cont.	25.637	31.315	28.476	22.937	32.988	27.963
	PB250 (FB+40 days)	30.651	36.410	33.530	33.833	35.661	34.747
	PB500 (FB+40 days)	37.497	45.472	41.485	38.440	37.579	38.009
	PB250 (FB+80 days)	37.358	36.917	37.138	31.005	45.000	38.003
	PB500 (FB+80 days)	44.348	44.541	44.444	29.640	49.407	39.524
(T) average		35.098	39.608		31.171	42.923	

L.S.D	(T)	(DXS)	(TXDXS)	(T)	(DXS)	(TXDXS)
0.05	0.043	0.138	0.194	0.310	0.981	1.387
0.01	0.058	0.182	0.258	0.411	1.301	1.839

Table (11): Effect of preharvest spraying (S) and postharvest dipping (D) treatments on reducing sugars (%) of "Anna" apple fruits during cold storage.

Treatments		Time (T) days					
Dip. (D)	Spray (S)	First season			Second season		
		0	75	(DXS) average	0	75	(DXS) average
Tap water	Control	25.247	28.160	26.703	22.200	32.387	27.293
	PB250 (FB+40 days)	30.120	32.940	31.530	33.237	38.967	36.102
	PB500 (FB+40 days)	37.010	39.597	38.303	37.330	38.817	38.073
	PB250 (FB+80 days)	36.450	37.000	36.725	30.230	43.477	36.853
	PB500 (FB+80 days)	43.800	43.893	43.847	28.530	39.927	34.228
$CaCl_2$ 3%	Control	25.247	33.750	29.498	22.200	35.603	28.902
	PB250 (FB+40 days)	30.120	35.293	32.707	33.237	50.513	41.875
	PB500 (FB+40 days)	37.010	39.933	38.472	37.330	41.803	39.567
	PB250 (FB+80 days)	36.450	44.850	40.650	30.230	50.117	40.173
	PB500 (FB+80 days)	43.800	45.583	44.692	28.530	48.080	38.305
$CaCl_2$ 3% Vac.	Control	25.247	34.937	30.092	22.200	36.403	29.302
	PB250 (FB+40 days)	30.120	36.230	33.175	33.237	49.703	41.470
	PB500 (FB+40 days)	37.010	47.617	42.313	37.330	43.323	40.327
	PB250 (FB+80 days)	36.450	45.027	40.738	30.230	50.770	40.500
	PB500 (FB+80 days)	43.800	46.310	45.055	28.530	51.017	39.773
Hot water	Cont.	25.247	30.873	28.060	22.200	32.593	27.397
	PB250 (FB+40 days)	30.120	35.717	32.918	33.237	37.767	35.502
	PB500 (FB+40 days)	37.010	45.010	41.010	37.330	37.387	37.358
	PB250 (FB+80 days)	36.450	36.550	36.500	30.230	44.633	37.432
	PB500 (FB+80 days)	43.800	44.120	43.960	28.530	49.030	38.780
(T) average		34.525	39.170		30.305	42.616	

L.S.D	First season (T)	First season (DXS)	First season (TXDXS)	Second season (T)	Second season (DXS)	Second season (TXDXS)
0.05	0.042	0.133	0.188	0.146	0.462	0.654
0.01	0.056	0.176	0.249	0.194	0.613	0.867

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التأثيرات المتجمعة لمعاملات الرش بالباكلوبيوترازول قبل الجمع وبعض معاملات الغمس بعد الجمع على الاحتفاظ بالجودة والقدرة التخزينية لثمار تفاح (آنا)

أميرة عبد الحميد الهـلالي[1] - ميرفت عبد المجيد الشيمي[2] - محمود السيد صبيـح[3]

١-محطة بحوث البساتين بالصباحية-الإسكندرية – معهد بحوث البساتين بالجيزة -جمهوريـة مصر العربية

٢- محطة بحوث البساتين سخا – كفر الشيخ - معهد بحوث البساتين بـالجيزة – جمهوريـة مصر العربية

٣- معهد بحوث البساتين بالجيزة - جمهورية مصر العربية

رشت أشجار تفاح أنا بالباكلوبيوترازول (PB) بتركيزى ٢٥٠ أو ٥٠٠ جزء في المليون بعد ٤٠ أو ٨٠ يوم من الأزهار الكامل أو تركت بدون رش (مقارنة). ثم جمعت الثمار المكتملة النمو لكل معاملة وغمست لمدة ٤دقائق في كل من المعاملات التالية ماء الصنبور (مقارنة) أو محلول كلوريد الكالسيوم ٣./. أو محلول كلوريد كالسيوم ٣./. تحت تفريغ أو ماء ساخن (٤٠م). ثم خزنت الثمار عند ٣م ورطوبة نسبية قدرها ٨٥-٩٠./. .

وقد أوضحت النتائج الآتي:

- في كلا موسمى الدراسة، بتقدم فترة التخزين انخفض معنويا كل من فيتامين ج، حامض الماليك والسكريات الغير مختزلة والعناصر المعدنية (النتروجين،الفوسفور والبوتاسيوم،الماغنسيوم) بينما ارتفعت النسب المئوية للفقد فى الوزن، إصابات الثمار و السكريات المختزلة و كذلك السكريات الكلية و ذلك فى جميع المعاملات.
- أظهر الجمع بين معاملات الرش والغمس تأثير كبير على تحسين تخزين الثمار بالمقارنة باستخدام كل منهم منفردا واتضح ذلك التأثير من خلال القدرة على خفض النسبة المئوية للفقد في الوزن، الإصابات والاحتفاظ بالحموضة والسكريات الكلية والمختزلة، بينما لم يكن هذا التأثير واضحا بالنسبة للفيتامين ج و السكريات الغير مختزلة والمحتويات المعدنية.
- معاملات كلوريد الكالسيوم خاصة تحت التفريغ كانت افضل من الماء الساخن وذلك عندما استخدمت مع معاملات الرش.
- عموما معاملات الرش الأربعة كلها تقريبا لها نفس التأثير على القدرة التخزينية وذلك عندما استخدمت منفردة بالرغم من أن المعاملة المبكرة (بعد الأزهار التام بـ ٤٠يوم) أظهرت قدرة أكبر في خفض إصابات الثمار.
- ظهرت إصابات الثمار لاول مرة عند ٣٠يوم من التخزين في الثمار المعاملة بمعاملات الغمس فقط أو الغير معاملة (ثمار الأشجار التي لم ترش بـ PB) و لم تظهر حتى عند ٤٥ يوم من التخزين في الثمار المعاملة بـ PB بتركيز ٢٥٠جزء في المليون (في كلا موعدى المعاملة) + أي معاملة من معاملات ما بعد الجمع، في حين أظهرت باقي المعاملات الإصابات عند ٤٥ يوم من التخزين.