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EFFECT OF CALCIUM CHLORIDE AND OTHER POST-HARVEST TREATMENTS ON QUALITY OF AWAIS MANGO FRUITS DURING AND AFTER COLD STORAGE

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ABSTRACT: In 1996 and 1997 seasons, mature (M) and start-to-ripe (R) Awais mango fruits were treated with :1)M fruits were soaked in TBZ (theobendazol) at 1000 ppm for 5min., then bagged in perforated (0.25%of area) polyethylene (P.PE) bags, i.e. (TBZ+P.PE); 2)as in 1 but after TBZ, M fruits were soaked in calcium chloride (Ca) 8% for 15 min., i.e. (TBZ+Ca+P.PE); 3) as in 1 but on R fruits; 4) as in 2 but on R fruits; 5) R fruits were soaked in hot (52°C) TBZ at 1000ppm for 5min. (H.TBZ), then soaked in (Ca) and bagged in sealed polyethylene bags (S.PE) ,i.e. (H.TBZ+Ca+S.PE).Treated M fruits were stored at 13±1°C, while R fruits were stored at 8±1°C for 7 weeks. After each week, samples were taken to evaluate cold storage period effects. Moreover, beginning from the third week of cold storage, fruit samples were kept on shelves for five days under 20°C and 60-70% RH to detect shelf life effect.

The obtained results, generally, revealed higher storability of start-to-ripe Awais mango fruits compared with mature ones. In addition, the most promising results were obtained by the start-to-ripe fruits treated with TBZ (Thiobendazole) 1000 ppm for 5 min.,then soaked in calcium chloride 8% for 15 min., then packed in perforated (0.25%) polyethylene bags, and stored for five weeks under 8°C. Fruits of this treatment indicated lower fresh weight losses, fruit decay index and peel color index, while were of relatively higher firmness, panel test index and total soluble solids percentages as compared with the other tested treatments.

INTRODUCTION

Mango (*Mangifera indica*, L.) is one of the most important fruit crops in Egypt. Awais is an excellent mango cultivar which is characterized by favorite fruit quality, high yield and short harvesting season during September. Mango fruits, generally, have a short post-harvest life. Cold storage can be the most promising solution to prolong the local marketing season and increasing the opportunity of mango exportation.

Post-harvest dipping in calcium chloride solutions can correct its

pre-harvest deficiency in fruits. Dipping mango fruits for 15 min. in aqueous solutions containing calcium nitrate or calcium chloride extended edible quality to reach around ten days compared with pre-harvest spraying with the same chemicals (eight days) and the control (four days) (Singh *et al.*, 1987). Calcium nitrate at 2% reduced weight loss in mango fruits (Kaushik *et al.*, 1991). In addition, Color development, textural softening and fruit weight losses of mango cv. Willard were retarded during cold storage condition in fruit dipped in cold solution containing up to 8% $CaCl_2$ for two hours (Suntharalingam, 1996). However, hot water treatment (52±2°C) using 1% $CaCl_2$ was the most effective in retarding fruit ripening, and spoilage (Abdul-Gofur*et al.*,1997). $CaCl_2$ 6% was the most effective in reducing weight losses and improving color and quality of stored mango cv. Dashehari (Mahajan and Sharma, 1995). Moreover, best storage life of mango cv. Alfonso was achieved by Thiobendazole (TBZ) at 1000 ppm which surpassed other fungicides treatments (Shivarama *et al.*,1989)

The present investigation was outlined to study the effect of dipping mango fruits in $CaCl_2$ and TBZ followed by polyethylene packing of mature or start-to-ripe Awais mango fruits before cold storage. The effect of tested treatments on fresh weight losses, peel color, fruit decay, firmness, respiration rate, panel test, total soluble solids and activated acidity were considered to evaluate the tested treatments during cold storage periods and after five days shelf life.

MATERIALS AND METHODS

This study has been carried out during 1996 and 1997 seasons on Awais mango fruits harvested on September 2nd from a private orchard at Anshas, Sharkeya Governorate. The orchard soil was sandy and the trees were more than 60 years old. The trees were grafted onto seedling rootstock and irrigated with Nile water using the traditional basin irrigation system, and uniformly received the usual horticultural practices. Harvesting took place in the morning. Fruits were harvested in two stages, i.e. mature green and started to ripe fruits, with a slight yellow blush color. The fruits were then directly taken to Post-harvest Laboratory in Hort. Dept., Fac. Agric. Zagazig Univ. All fruits were washed with water and soap, and then rinsed by water to remove soap residues. Fruits of

each stage were divided between the following treatments:1) Mature (M) fruits were soaked in TBZ (Thiobendazol) at 1000 ppm for 5min., then packed in perforated (0.25% of area) polyethylene bags (P.PE), the treatment was referred to as (TBZ+P.PE); 2)as in 1 but after TBZ treatment, fruits were soaked in calcium chloride (Ca) 8% for 15min.,i.e.(TBZ+Ca+P.PE); 3)as in 1 but on start-to-ripe (R) fruits; 4)as in 2 but on R fruits; 5) R fruits were soaked in hot (52°C) TBZ solution at 1000ppm for 5min.(H.TBZ), then soaked in Ca (8%) for 15min. and packed in sealed low density polyethylene bags (S.PE), i.e. (H.TBZ+Ca+ S.PE). This treatment was applied by sub-merging naked fruits in stirred hot water bath at 52° C for 5 min. after the pulp temperature next to the endocarp reached 52°C, then trans-formed immediately to cold water.

The number of experimental M fruits was 420, divided into 2 main groups (treatments); i.e.210 fruits per treatment shared between 3 replicates (70 fruits /replicate). In addition, 3 groups (treatments) of R fruits (i.e.630 fruits) were used.

All treatments using M fruits were stored in cold room at 13±1°C, while the R fruits were stored in cold room at 8±1°C. Cold storage continued for 7 weeks. After each week of cold storage, samples of each treatment were taken to evaluate cold storage period effects. Moreover, beginning from the third week of cold storage, samples were taken to investigate fruit behavior during shelf life under conditions of 20°C and 60-70%RH in an incubator for five days (i.e. the same as supermarket conditions). Evaluation of cold storage and the following shelf life periods on Awais mango fruits was carried out through the following parameters:

Fresh weight losses percentages (FWL): The fruits were weighed before cold storage, after each week of cold storage and after five days of the shelf life; FWL were calculated.

Peel color index (PCI): It was subjectively scored on scale of 0 to 10 where 0 = 100% green; 2 = 1-25% yellow; 4 = 26-40%; 6 = 41-60%; 8 = 61-80%; 10 = 81-100% yellow. Average values were calculated.

Fruit decay index (FDI): It was subjectively scored on a scale of 0 to 8, where 0 = without decay, 2 = spot, 5 = 25% and 8 = 50% of peel surface was decayed. Average values were calculated.

Panel test index (PTI): Each replicate was judged by five persons who gave the score as follows: 4=excellent test; 3= very good test;

2=good test; 1=acceptable test and 0=bad test. Average values of the five persons were calculated.

Fruit pulp firmness: It was determined on 3 fruits per replicate; three measurements were taken on each fruit after removing peel and using Push Pull dynamo-meter McCormick (Model F T327) with plungertip 5/16. The average firmness was expressed as lb.

Juice total soluble solids percentage (TSS): Three fruits were picked from each sample, the juice was extracted and the TSS (%) was determined using a hand refractometer.

Juice active acidity (pH value): It was determined using pH meter (Style Hanna 8514).

Respiration rate: It was determined in the 2nd and 4th weeks of cold storage periods on three fruits per replicate, which were placed in 3.8 L glass jar (respiratory chambers) mounted in groups of four pieces, three of which were used for the respiration rate while the fourth was used as a blank. The air stream from each jar, metered through dispersion tube meter (model, Val Borg Instruments, NY) was passed through two dispersion tubes connected in series (double trap) containing 0.1*N* barium hydroxide and 0.2% barium chloride solution. CO_2 output was recorded titrimetrically and respiration rate was calculated as mg CO_2 / kg /h. Respiration rate of fruits were determined under 20°C.

The complete randomized block design with 3 replicates and with factorial arrangement was followed throughout the whole work (Snedecor and Cochran, 1980). The means representing the effect of tested treatment, storage periods and their interactions were compared using the New-LSD method at 0.05.

RESULTS AND DISCUSSION

1. Fresh Weight Losses (FWL)

A. During cold storage periods

Data in Table 1 show that the tested treatments significantly affected FWL during cold storage periods in both seasons. The uppermost losses, in both seasons, were recorded by the M fruits treated with (TBZ+P.PE), while, the lowermost FWL resulted from R fruits treated with (H.TBZ + Ca + S.PE) in both seasons. The other tested treatments showed inbetween values in both seasons. Worthwhile, FWL of R fruits was significantly decreased with the treatment (TBZ+Ca+P.PE) in both seasons compared with (TBZ+P.PE). Also, FWL of M fruits were significantly decreased with the treatment (TBZ+Ca+P.PE) in the second season compared with

(TBZ+P.PE). Such effect might be due to the effect of Ca ion in the treatment solution which increases stability of calcium pectate in the middle lamella between cells and / or to Ca activity as inter molecular binding agent which stabilizes pectin-protein complexes of the middle lamella (Dey and Brinson, 1984). In addition, the reduction in FWL with packing in sealed PE bags might be attributed to increasing relative humidity (RH) in the bags and decreasing water losses from fruits through lenticels.

The interaction (Period × Treatment) was significant in both seasons. The highest FWL resulted from the first four treatments in the weeks from five to seven as well as from the first three treatments in the 4th week. This was true in both seasons. On the other hand, the least values were recorded by most of the tested treatments during the 1st and 2nd weeks of cold storage period.

B. After five days shelf life

The tested treatments significantly affected FWL after five days shelf life in both seasons. The highest losses, were recorded by R fruits treated with (H.TBZ+Ca+S.PE) while, the lowest FWL resulted from R fruits treated with (TBZ+Ca+P.PE) . The other tested treatments recorded inbetween values. This was true in both seasons. In this respect, differences between R fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) were significant in both seasons. Also, differences between M fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) were significant in the second season only.

Fresh weight losses were significantly decreased with increasing the cold storage period in both seasons. The highest losses occurred in the 3rd week of cold storage in both seasons. While, the least FWL resulted in the 6th and 7th weeks of cold storage without significant differences between them in both seasons. The other periods came inbetween.

The interaction (Period ×Treatment) was significant in both seasons. The highest losses occurred by M fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) in the 3rd week as well as by R fruits treated with (H.TBZ+Ca+P.PE) in the 3rd and 4th weeks. This was true in both seasons. In addition, the differences between treatment (1) in the weeks from three to five and the treatment (5) in the same period were insignificant in the second season. On the other hand, the lowermost values were recorded by

Table 1. Effect of some post-harvest treatments on fresh weight losses and firmness of mature and start-to-ripe Awais mango fruits during cold storage period and after five days shelf life (1996 and 1997 seasons).

Fruits	Treatment*	Fresh weight losses % (FWL)														Firmness (lb)							
		Cold storage period (weeks)							T.	Shelf life					T.	Cold storage			T.	Shelf life			T.
		1	2	3	4	5	6	7	Av.	3	4	5	6	7	Av.	4	5	6	av.	4	5	6	av.
		Frist seson 1996																					
Mature	(1)TBZ+P.PE	1.3	2.9	4.1	5.7	6.1	6.5	7.2	4.8	2.1	1.9	1.7	1.6	1.4	1.7	2.0	1.7	1.0	1.6	1.8	1.1	0.8	1.2
Mature	(2)TBZ+Ca+PPE	1.3	2.1	4.1	5.1	5.7	6.3	6.9	4.5	2.0	1.6	1.6	1.4	1.4	1.6	2.7	2.0	1.2	2.0	2.1	1.8	1.0	1.6
Ripe	(3)TBZ+P.PE	1.1	2.1	3.2	5.1	5.4	5.9	6.5	4.2	1.9	1.5	1.4	1.2	0.9	1.4	3.0	1.9	1.0	2.0	2.0	1.7	0.7	1.5
Ripe	(4)TBZ+Ca+P.PE	1.2	2.3	3.2	4.1	4.6	5.1	5.8	3.8	1.8	1.5	1.3	1.0	0.7	1.3	4.1	3.7	1.3	3.0	3.0	2.5	1.2	2.2
Ripe	(5)H.TBZ+Ca+S.PE	0.0	1.1	1.3	1.4	1.5	2.4	2.8	1.5	2.9	2.6	1.7	1.6	1.5	2.1	3.6	3.0	1.4	2.7	3.2	2.8	1.3	2.4
	Period av.(P)	1.0	2.1	3.2	4.3	4.7	5.2	5.8		2.1	1.8	1.5	1.4	1.2		3.1	2.5	1.2		2.4	2.0	1.0	
	New LSD 0.05	P=1.08			T=0.39		P×T=2.87			P=0.27		T=0.22		P×T=0.93		P=0.55 T=0.87 P×T=1.11				P=0.36 T=0.27 P×T=1.31			
		second seson 1997																					
Mature	(1)TBZ+P.PE	1.1	3.1	4.2	5.6	6.2	6.6	7.0	4.8	2.2	2.0	1.8	1.6	1.5	1.8	2.0	1.6	1.0	1.5	1.7	1.0	0.7	1.1
Mature	(2)TBZ+Ca+PPE	1.1	2.0	3.9	4.9	5.6	6.4	7.0	4.4	1.9	1.5	1.4	1.4	1.3	1.5	2.7	2.1	1.3	2.0	2.2	1.9	1.1	1.7
Ripe	(3)TBZ+P.PE	1.1	2.0	3.3	5.0	5.7	6.0	6.5	4.2	2.0	1.6	1.5	1.3	0.9	1.5	2.9	1.8	1.0	1.9	1.8	1.1	0.6	1.2
Ripe	(4)TBZ+Ca+P.PE	1.1	2.2	3.4	4.2	4.8	5.2	5.7	3.8	1.7	1.4	1.2	0.9	0.6	1.2	4.0	3.6	1.2	2.9	2.7	2.4	1.1	2.1
Ripe	(5)H.TBZ+Ca+S.PE	0.0	1.0	1.2	1.4	1.6	2.3	2.7	1.4	2.8	2.5	1.8	1.6	1.5	2.0	3.8	3.0	1.5	2.8	3.0	2.6	1.3	2.3
	Period av.(P)	0.9	2.1	3.2	4.2	4.8	5.3	5.8		2.0	1.6	1.5	1.4	1.2		3.1	2.4	1.2		2.3	1.8	1.0	
	New LSD 0.05	P=0.96			T=0.29		P×T=3.01			P=0.34		T=0.29		P×T=1.11		P=0.61 T=0.71 P×T=1.07				P=0.48 T=0.45 P×T=1.27			

TBZ= soaking in (Thiabendazole) 1000ppm for 5 min.; P.PE=packing in perforated (0.25% of area) polyethylene bags.; S.PE=packing in sealed PE bags.; H.TBZ=soaking in hot solution of TBZ (1000ppm) at 52°C for 5 min.; Ca=soaking in Calcium chloride 8% for 15 min.;

all tested treatments during the 6th and 7th weeks of cold storage as well as by treatment from (2) to (4) in the weeks from four to seven without significant differences among them in both seasons. The other values were inbetween.

The results are in line with those obtained by Singh *et al* (1987), Kaushik *et al* (1991), Mahajan and Sharma (1995) and Suntharalingam (1996) working on different mango cvs.

2. Fruit Firmness

A. During cold storage periods

The data clarify that the tested treatments significantly affected fruit firmness in both seasons. The highest firmness, in both seasons, were recorded by R fruits treated with (TBZ+Ca+P.PE) and (H.TBZ+Ca+S.PE) without significant differences between them in both seasons. The lowest fruit firmness resulted from the other three treatments without significant differences between them in both seasons. Worthwhile, firmness of R fruits treated with (TBZ+Ca+P.PE) was significantly higher than that of R fruits treated with (TBZ+P.PE) in both seasons. Also, M fruits treated with (TBZ+Ca+P.PE) indicated insignificantly higher firmness in both seasons.

The cold storage period also significantly affected fruit firmness in both seasons. As expected, the highest firmness was observed in the 4th week in both seasons. The lowest fruit firmness resulted after six weeks of cold storage in both seasons. In the 5th week the values came inbetween in both seasons.

The interaction (Period ×Treatment) was significant in both seasons. The uppermost values resulted from R fruits treated with (TBZ+Ca+P.PE) and (H.TBZ+Ca+S.PE) in the 4th and 5th weeks without significant differences between them in both seasons. On the other hand, the lowermost values were recorded by all treatments in the 6th week, as well as by the treatments from (1) to (3) in the 5th week and the 1st treatment in the 4th week. This was true in both seasons. Meanwhile, inbetween values were detected in the 4th week by treatments (2) and (3) in the first and second seasons, respectively.

B. After five days shelf life

The tested treatments significantly affected fruit firmness after five days shelf life in both seasons. The highest firmness values, in both seasons, were recorded by R fruits treated with (TBZ+Ca+P.PE) and (H.TBZ+Ca+S.PE) without significant differences between them. The lowest firmness values resulted from treatment (TBZ+P.PE) with M fruits in both seasons and R fruits

in the second season only. The other tested treatments gave inbetween values. Worthwhile, the differences between M fruits treated with (TBZ+Ca+ P.PE) and (TBZ+P.PE) was significant in both seasons. Also, the differences between R fruits treated with (TBZ+P.PE) and both (H.TBZ+Ca+S.PE) and (TBZ+Ca+P.PE) were significant in both seasons.

The cold storage periods also significantly affected fruit firmness after five days shelf life in both seasons. As expected, the highest fruit firmness resulted in the 4th week of cold storage in both seasons. Whereas, the lowest firmness exhibited in the 6th week. Meanwhile, fruit firmness after five weeks of cold storage, came inbetween.

The interaction (Period × Treatment) was significant in both seasons. The uppermost values resulted from the treatments from (2) to (5) in the 4th week, as well as, treatments (4) and (5) in the 5th week in both seasons; in addition to the 2nd treatment in the 5th week, in the second season only. On the other hand, the lowermost values were recorded by all tested treatments in the 6th week, as well as, the 1st treatment after the 4th to 6th weeks of cold storage , and the 3rd treatment in the 5th week. This was true in both seasons.

The obtained results revealed that treatments implying Ca ions increased fruit firmness during cold storage and after five days shelf life. This might be due to the effect of Ca ions as inter molecular binding agent that stabilizes pectin-protein complexes of the middle lamella (Dey and Brison,1984) and/or to the formation of a cross-bridge between uronic acids which may make the cell wall less accessible to enzymes in the pulp that cause softening (Sams *et al.*, 1993). The obtained results are in agreement with those reported by Suntharalingam (1996) on mango cv. Willard.

3. Peel Color Index (PCI)

A. During cold storage period

Data in Table 2 show that the tested treatments significantly affected PCI during cold storage periods in both seasons. The highest PCI, in both seasons, were recorded by M fruits treated with (TBZ+P.PE) as well as R fruits treated with both (TBZ+P.PE) and (TBZ+Ca+P.PE) without significant differences between them. The lowest PCI resulted from R fruits treated with (H.TBZ+Ca+S.PE) in both seasons. Moreover, M fruits treated with (TBZ+Ca+P.PE) gave inbetween values in both seasons. Worthwhile, differences between M fruits

treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) were significant in both seasons. Also, differences between R fruits treated with (H.TBZ+Ca+S.PE) and R fruits treated with either (TBZ+P.PE) or (TBZ+Ca+P.PE) were significant in both seasons.

The cold storage period also significantly affected PCI in both seasons. The highest PCI resulted in the 6th and 7th weeks of cold storage without significant differences between them in both seasons. However, the least PCI came after three weeks of cold storage in both seasons. The other periods came inbetween.

The interaction (Period × Treatment) was significant in both seasons. The uppermost values were recorded by the treatments from (1) to (4) in the 7th week, as well as, treatments (1), (3) and (4) in the 4th to 6th weeks of cold storage in both seasons. However, the lowermost values were resulted by treatment (5) in the 1st to 5th weeks in both seasons and treatments (1) and (2) in the 1st week of cold storage in the second season only. Meanwhile, inbetween values were recorded by treatment (2) in the 2nd to 6th weeks of cold storage in both seasons, as well as, most of the tested treatments in the 1st and 2nd weeks of cold storage in both seasons.

B. After five days shelf life

The tested treatments significantly affected PCI after five days shelf life following to cold storage periods in both seasons. The highest PCI, in both seasons, were recorded by M fruits treated with (TBZ+P.PE) as well as R fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) without significant differences among them. The lowest PCI resulted from R fruits treated with (H.TBZ+Ca+S.PE) in both seasons. Moreover, M fruits treated with (TBZ+Ca+P.PE) gave inbetween values in both seasons. Worthwhile, differences between M fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) were significant in both seasons. Also, differences between R fruits treated with (H.TBZ+Ca+S.PE) and R fruits treated with either (TBZ+P.PE) or (TBZ+Ca+P.PE) were significant in both seasons.

The cold storage period also significantly affected PCI after five days shelf life following the cold storage periods in both seasons. As expected, the highest PCI resulted in the 5th to 7th weeks of cold storage in the 1st season, as well as, in the 6th and 7th weeks in the 2nd season without significant differences between them. On the other hand, the least PCI exhibited in the earliest samples (after three weeks of cold storage

period) in both seasons. The other periods came inbetween.

The interaction (Period×Treatment) was significant in both seasons. The highest values resulted from all tested treatments in the 5th to 7th week, as well as, from treatments (1),(3) and (4) in the 3rd and 4th weeks. This was true in both seasons. On the other hand, the least values were recorded by treatment (5) in the 3rd and 4th weeks in both seasons. However, inbetween values were recorded by treatment (2) in the 3rd week in both seasons and the same treatment in the 4th week in the 2nd season.

Generally, the obtained results indicated that Ca ions in the treatment solution retarded PCI in M fruits to the 6th week of cold storage, as well as, after five days shelf life following 3 or 4 weeks of cold storage. Also, Ca ions + S.PE retarded PCI in R fruits in all tested cold storage periods and after five days shelf life following the 3rd and 4th weeks of cold storage periods.

These results are in harmony with those reported by Suntharalingam (1996), who found that color development, textural softening and fruit weight losses of mango cv. Willard were retarded during cold storage condition in fruits dipped in cold solution containing up to 8% calcium chloride for two hours. Also, maximum inhibition of carotenoids formation occurred in heated mango fruits at 54°C (Zambrano and Materano, 1998). On the other hand, the results contradict with Mahajan and Sharma (1995), who found that calcium chloride solution at 6%, was the most effective in improving fruit color.

4. Panel Test Index (PTI)

A. During cold storage periods

Data in Table 2 also show that the tested treatments significantly affected PTI in the 1st season only when the highest PTI values were recorded by the first four treatments. While, the least value was recorded by the 5th treatment.

The effect of cold storage period and the interaction (Period×Treatment) was insignificant in both seasons.

B. After five days shelf life

The effect of the tested treatments on fruit PTI after five days shelf life was significant in the 2nd season only; the highest PTI values were recorded by the first four treatments without significant differences among them. While, the least value was detected by treatment (5).

The effect of cold storage period and the interaction (Period×Treatment) on fruit PTI after five days shelf life were insignificant in both seasons.

Table 2. Effect of some post-harvest treatments on peel color index and panel test index of mature and start-to-ripe Awais mango fruits during cold storage period and after 5-days shelf life (1996 and 1997 seasons).

Fruits	Treatment*	Peel color index (PCI)														Panel test index (PTI)									
		Cold storage period (weeks)							T.	Shelf life					T.	Cold storage period (weeks)				T.	Shelf life				T.
		1	2	3	4	5	6	7	Av.	3	4	5	6	7	Av.	4	5	6	7	Av.	4	5	6	7	Av.
		first season 1996																							
Mature	(1)TBZ+P.PE	2.3	4.7	6.7	7.1	7.3	8.0	8.0	6.3	7.4	8.0	8.0	8.0	8.0	7.9	2.6	3.0	3.0	3.0	2.9	3.0	3.0	3.0	3.0	3.0
Mature	(2)TBZ+Ca+PPE	2.7	3.0	3.4	3.5	3.9	5.3	7.0	4.1	5.6	6.5	6.9	7.0	8.0	6.8	2.5	3.0	3.0	3.0	2.9	3.0	3.0	3.0	3.0	3.0
Ripe	(3)TBZ+P.PE	3.2	5.7	5.8	7.0	7.5	8.0	8.0	6.5	7.2	8.0	8.0	8.0	8.0	7.8	2.0	3.0	3.0	3.0	2.7	3.0	3.0	3.0	3.0	3.0
Ripe	(4)TBZ+Ca+P.PE	3.3	4.7	5.5	6.1	6.3	7.1	8.0	5.8	7.1	7.5	8.0	8.0	8.0	7.7	2.2	3.0	3.0	3.0	2.8	3.0	3.0	3.0	3.0	3.0
Ripe	(5)H.TBZ+Ca+S.PE	0.0	0.0	0.0	0.0	1.6	3.0	3.6	1.2	3.1	4.1	6.9	7.2	7.3	5.7	3.0	2.9	2.3	2.0	2.5	2.6	2.6	2.2	2.0	2.4
	Period av.(P)	2.3	3.6	4.3	4.7	5.3	6.3	6.9		6.1	6.8	7.6	7.6	7.9		2.5	3.0	2.9	2.8		2.9	2.9	2.8	2.8	
	New LSD 0.05	P=1.01			T=1.13			P×T=2.12		P=0.56			T=1.03		P×T=2.01	P=N.S.		T=0.38		P×T=N.S.	P=N.S.		T=N.S.		P×T=N.S.
		second season 1997																							
Mature	(1)TBZ+P.PE	2.3	4.5	6.2	7.0	7.2	8.0	8.0	6.2	7.2	8.0	8.0	8.0	8.0	7.8	2.5	3.0	3.0	3.0	2.9	3.0	3.0	3.0	3.0	3.0
Mature	(2)TBZ+Ca+PPE	2.4	2.9	3.3	3.6	4.0	5.1	7.2	4.1	5.1	5.9	6.2	7.0	8.0	6.4	2.4	3.0	3.0	3.0	2.8	3.0	3.0	3.0	3.0	3.0
Ripe	(3)TBZ+P.PE	3.0	5.6	6.4	6.9	7.4	8.0	8.0	6.5	7.5	8.0	8.0	8.0	8.0	7.9	2.0	3.0	3.0	3.0	2.7	3.0	3.0	3.0	3.0	3.0
Ripe	(4)TBZ+Ca+P.PE	3.2	4.3	5.5	6.1	6.3	7.3	8.0	5.8	6.9	7.1	8.0	8.0	8.0	7.6	2.1	2.8	3.0	3.0	2.7	3.0	3.0	3.0	3.0	3.0
Ripe	(5)H.TBZ+Ca+S.PE	0.0	0.0	0.0	0.0	1.7	2.8	3.4	1.1	3.0	4.0	6.5	7.1	7.2	5.5	3.0	2.9	2.3	2.0	2.5	2.5	2.5	2.3	2.0	2.3
	Period av.(P)	2.2	3.5	4.3	4.7	5.3	6.2	6.9		5.9	6.6	7.3	7.6	7.8		2.4	2.9	2.9	2.8		2.9	2.9	2.9	2.8	
	New LSD 0.05	P=1.18			T=1.92			P×T=2.69		P=0.41			T=1.12		P×T=1.87	P=N.S.		T=N.S.		P×T=N.S.	P=N.S.		T=0.61		P×T=N.S.

TBZ= soaking in (Thobendazole)1000ppm for 5 min.; P.PE=packing in perforated (0.25% of area) polyethylene bags.; S.PE=packing in sealed PE bags.; H.TBZ=soaking in hot solution of TBZ (1000ppm) at 52°C for 5 min.; Ca=soaking in Calcium chloride 8% for 15 min.;

5. Fruit Decay Index (FDI)

A. During cold storage periods

Data in Table 3 show that the tested treatments significantly affected FDI in both seasons. The highest values resulted from M fruits treated with (TBZ+P.PE). The least values were recorded by R fruits treated with (H.TBZ+Ca+P.PE).The other tested treatments indicated inbetween values. This was true in both seasons. Moreover, the differences between M fruits treated with (TBZ+P.PE) and (TBZ+Ca+ P.PE) were significant in both seasons. Also, the differences between R fruits treated with (TBZ+P.PE) and those treated with either (TBZ+Ca+P.PE) or (H.TBZ+Ca+S.PE) were significant in both seasons. This indicated that the presence of Ca ions in the treatment decreased FDI during cold storage. This might be due to the effect of Ca ions as inter molecular binding agent that stabilizes pectin-protein complexes of the middle lamella (Dey and Brison,1984) and/or to the formation of a cross-bridge between uronic acids which may make the cell wall less accessible to enzymes in the pulp that cause softening (Sams *et al.*, 1993).

The cold storage period also significantly affected FDI in both seasons. The highest FDI resulted in the 6^{th} and 7^{th} weeks of cold storage without significant differences between them in both seasons. On the other hand, FDI was nil after one week of cold storage, while gradually increased afterwards.

The interaction (Period×Treatment) was significant in both seasons. The uppermost FDI resulted from the treatments from (1) to (4) in the 6^{th} and 7^{th} weeks of cold storage without significant differences among them in both seasons. On the other hand, the lowermost FDI values were recorded by all tested treatments in the first four weeks of cold storage without significant differences among them in most cases. Meanwhile, inbetween values were recorded by most of the tested treatments, in the 6^{th} and 7^{th} weeks in both seasons.

B. After five days shelf life

The data also show that the tested treatments significantly affected FDI after five days shelf life following each cold storage period in both seasons. The highest FDI, in both seasons, were recorded by M fruits treated with (TBZ+P.PE) and R fruits treated with either (TBZ+P.PE) or (TBZ+Ca+P.PE) without significant differences among them in both seasons. Meanwhile, M fruits treated with (TBZ+Ca+P.PE) and

Table 3. Effect of some post-harvest treatments on decay index, and respiration rate of mature and start-toripe Awais mango fruits during cold storage period and after five days shelf life (1996 and 1997 seasons).

Fruits	Treatment*	Fruit decay index (FDI)														Respiration rate, mg Co2 / kg / hours.		
		Cold storage period (weeks)							T.	Shelf life					T.	Cold st. period w.		T. Av.
		1	2	3	4	5	6	7	Av.	3	4	5	6	7	Av.	2	4	
		Frist seson 1996																
Mature	(1)TBZ+P.PE	0.0	1.4	1.5	2.0	3.1	3.9	4.9	2.4	2.1	4.0	4.9	6.3	8.0	5.1	3.09	2.58	2.83
Mature	(2)TBZ+Ca+PPE	0.0	1.3	1.4	1.8	2.3	3.5	4.0	2.0	2.0	2.9	3.7	4.2	7.1	4.0	3.69	2.54	3.11
Ripe	(3)TBZ+P.PE	0.0	1.6	1.7	1.9	2.2	3.7	4.5	2.2	2.3	4.2	5.0	7.0	8.0	5.3	2.21	2.33	2.27
Ripe	(4)TBZ+Ca+P.PE	0.0	1.2	1.5	1.7	2.2	3.4	4.0	2.0	1.9	3.1	4.0	5.3	8.0	4.5	2.73	2.13	2.43
Ripe	(5)H.TBZ+Ca+S.PE	0.0	0.0	0.0	0.0	0.6	2.5	2.6	0.8	1.0	2.3	3.1	4.2	4.5	3.0	2.39	2.41	2.40
	Period av.(P)	0.0	1.1	1.2	1.5	2.1	3.4	4.0		1.9	3.3	4.1	5.4	7.1		2.82	2.40	
	New LSD 0.05	P=0.98		T=0.19		P×T=1.97				P=1.21		T=1.16		P×T=2.91		P=0.38	T=N.S.	P×T=N.S.
		second season 1997																
Mature	(1)TBZ+P.PE	0.0	1.3	1.5	2.1	2.9	3.8	5.1	2.4	2.0	3.9	5.0	6.5	8.0	5.1	3.19	2.69	2.94
Mature	(2)TBZ+Ca+PPE	0.0	1.2	1.3	1.9	2.3	3.2	4.1	2.0	1.8	2.8	3.9	4.3	7.3	4.0	3.21	2.59	2.90
Ripe	(3)TBZ+P.PE	0.0	1.5	1.6	1.8	2.5	3.4	4.6	2.2	2.2	4.0	5.1	6.7	8.0	5.2	2.21	2.53	2.37
Ripe	(4)TBZ+Ca+P.PE	0.0	1.1	1.4	1.7	2.1	3.3	4.1	1.9	1.8	3.3	4.1	5.2	8.0	4.5	2.73	2.01	2.37
Ripe	(5)H.TBZ+Ca+S.PE	0.0	0.0	0.0	0.0	0.7	2.7	2.8	0.9	0.9	2.0	3.2	4.1	5.1	3.1	2.31	2.50	2.40
	Period av.(P)	0.0	1.0	1.2	1.5	2.1	3.3	4.1		1.7	3.2	4.3	5.4	7.3		2.73	2.46	
	New LSD 0.05	P=1.03		T=0.21		P×T=2.01				P=1.36		T=0.98		P×T=3.01		P=0.27	T=0.51	P×T=N.S.

TBZ=soaking in (Thiabendazole) 1000ppm for 5 min.; P.PE=packing in perforated (0.25% of area) polyethylene bags.; S.PE=packing in sealed PE bags.; H.TBZ=soaking in hot solution of TBZ (1000ppm) at 52°C for 5 min.; Ca=soaking in Calcium chloride 8% for 15 min.;

R fruits treated with (H.TBZ+Ca+P.PE) gave the lowest FDI. Worthwhile, the differences between M fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) were significant in the second season only. Also the differences between R fruits treated with (H.TBZ+Ca+S.PE) and those treated with either (TBZ+P.PE) or (TBZ+Ca+P.PE) were significant in both seasons.

The cold storage period also significantly affected FDI after five days shelf life in both seasons. As such, the highest FDI resulted in the 7th week of cold storage in both seasons. On the other hand, the least FDI resulted in the earliest samples, i.e., (after the 3rd week of cold storage). The other periods came inbetween.

The interaction (Period×Treatment) was significant in both seasons. The uppermost FDI values were recorded in the 7th week by the treatments from (1) to (4) in the first season, and all tested treatments in the second season, On the other hand, the lowermost FDI values were recorded by all tested treatments in the earlist sample, i.e. (3rd week) , as well as, treatments (2), (4) and (5) in the 4th week in both seasons. Meanwhile, inbetween values were recorded by most of the tested treatments in the 5th week of cold storage.

These results are in agreement with those reported by Abdul-Gofur,*et al.* (1997), who revealed that hot water treatment (52 ±2c°) using 1% $CaCl_2$ was the most effective treatment in retarding spoilage of mango fruits of cvs Fazli and Ashwina. Moreover, dipping mango fruits in hot water up to 55°C delayed ripening and controlled decay (Spadling and Reeder,1979 and Joseph and Aworth,1992).

6. Respiration rate

Data in Table 3 reveal that the tested treatments significantly affected fruit respiration rate during cold storage periods in the 2nd season only. As such, the uppermost respiration rate values were recorded by M fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) without significant differences between them. Meanwhile, R fruits treated with the last 3 treatments recorded the lowermost values without significant differences among them.

Cold storage period also significantly affected fruit respiration rate in both seasons. As such, the highest and lowest values, in both seasons, resulted in the earliest and latest samples, respectively.

The interaction (Period×Treatment) was insignificant in both seasons.

7. Total Soluble Solids Percentages (TSS)

A. During cold storage periods

Data in Table 4 show that the effects of the tested treatments, cold storage periods and their interaction were insignificant in both seasons.

B. After five days shelf life

The data also show that the tested treatments significantly affected TSS values after five days shelf life in both seasons. As such, the highest TSS values were recorded by the first four treatments, i.e. M and R fruits treated with (TBZ+P.PE) or (TBZ+Ca+P.PE) without significant differences among them in both seasons. Meanwhile, the lowermost TSS values were recorded by R fruits treated with (H.TBZ+Ca+ P.PE) in both seasons. In this respect, the effects of cold storage period and the interaction (Period×Treatment) on the TSS values were insignificant in both seasons.

8. Active Acidity (pH)

A. During cold storage periods

Data in Table 4 show that the tested treatments significantly affected juice pH values in the first season only; the highest pH values were recorded by M fruits treated with (TBZ+P.PE) and (TBZ+Ca+P.PE) without significant differences between them. Meanwhile, the least pH values resulted from R fruits treated with the last three treatments without significant differences among them.

The cold storage period also significantly affected pH values in both seasons. The highest pH values resulted in the 5^{th} to 7^{th} weeks of cold storage without significant differences between them in both seasons. On the other hand, the least pH values resulted after four weeks of cold storage in both seasons. Worthwhile, the differences in pH values between the 4^{th} and 5^{th} weeks of cold storage were insignificant in both seasons.

The interaction (Period×Treatment) was insignificant in both seasons.

B. After five days shelf life

Data in Table 4 also reveal that the tested treatments significantly affected pH values after five days shelf life in both seasons. The uppermost pH values were recorded by M fruits with the 1^{st} and 2^{nd} treatments, without significant differences between them in both seasons. Meanwhile, the lowermost pH values resulted from R fruits with the last three treatments, without significant differences among them in both seasons.

The cold storage period also significantly affected pH values after five days shelf life in both seasons. The highest pH values

Table 4.Effect of some post-harvest treatments on total soluble solids and active acidity of mature and start-to-ripe Awais mango fruits during cold storage period and after five days shelf life (1996 and 1997 seasons).

fruits	Treatment*	Total soluble solids %(TSS)										Active acidity (pH)									
		Cold storage				T.	Shelf life				T.	Cold storage				T.	Shelf life				T.
		4	5	6	7	av.	4	5	6	7	av.	4	5	6	7	av.	4	5	6	7	av.
		First season 1996																			
Mature	(1)TBZ+P.PE	19.8	22.5	23.0	23.0	22.1	21.7	22.9	23.0	23.0	22.6	5.31	5.35	5.39	5.40	5.36	5.39	5.40	5.41	5.41	5.40
	(2)TBZ+Ca+PPE	22.0	23.0	23.0	23.0	22.7	22.1	23.0	23.0	23.0	22.8	5.05	5.15	5.40	5.40	5.24	5.09	5.19	5.42	5.45	5.30
Ripe	(3)TBZ+P.PE	22.0	23.0	23.0	23.0	22.7	22.4	23.0	23.0	23.0	22.9	4.47	4.91	5.15	5.40	4.98	4.51	5.01	5.21	5.43	5.04
	(4)TBZ+Ca+P.PE	22.5	23.0	23.0	23.0	22.9	22.6	23.0	23.0	23.0	22.9	4.32	4.89	5.25	5.30	4.94	4.39	4.92	5.29	5.40	5.00
	(5)H.TBZ+Ca+S.PE	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.1	20.2	20.1	4.50	4.94	5.10	5.13	4.92	4.56	5.02	5.19	5.20	4.99
	Period av.(P)	21.2	22.3	22.4	22.4		21.8	22.4	22.4	22.4		4.73	5.05	5.26	5.33		4.79	5.11	5.30	5.38	
	New LSD 0.05	P=N.S. T=N.S. P×T=N.S.					P=N.S. T=2.07 P×T=N.S.					P=0.39 T=0.28 P×T=N.S.					P=0.47 T=0.32 P×T=N.S.				
		Second season 1997																			
Mature	(1)TBZ+P.PE	20.0	22.0	23.0	23.0	22.0	21.8	23.0	23.0	23.0	22.7	5.30	5.40	5.42	5.43	5.39	5.40	5.41	5.42	5.42	5.41
	(2)TBZ+Ca+PPE	21.9	22.5	23.0	23.0	22.6	22.0	23.0	23.0	23.0	22.7	4.91	5.05	5.38	5.41	5.19	5.11	5.17	5.40	5.44	5.28
Ripe	(3)TBZ+P.PE	21.8	22.0	23.0	23.0	22.4	22.6	22.9	23.0	23.0	22.9	4.37	4.81	5.10	5.40	4.92	4.49	4.98	5.19	5.40	5.01
	(4)TBZ+Ca+P.PE	22.4	23.0	23.0	23.0	22.8	22.6	23.0	23.0	23.0	22.9	4.31	4.80	5.05	5.37	4.88	4.37	4.89	5.18	5.39	4.94
	(5)H.TBZ+Ca+S.PE	20.1	20.1	20.2	20.2	20.1	20.1	20.1	20.3	20.3	20.2	4.51	4.99	5.00	5.10	4.90	4.54	5.03	5.15	5.19	4.98
	Period av.(P)	21.2	21.9	22.4	22.4		21.8	22.4	22.5	22.5		4.68	5.01	5.14	5.34		4.78	5.10	5.27	5.37	
	New LSD 0.05	P=N.S. T=N.S., P×T=N.S.					P=N.S. T=2.17 P×T=N.S.					P=0.45 T=N.S. P×T=N.S.					P=0.42 T=0.29 P×T=N.S.				

TBZ= soaking in (Thiobendazole) 1000ppm for 5 min.;P.PE=packing in perforated (0.25% of area) polyethylene bags.;S.PE=packing in sealed PE bags.; H.TBZ=soaking in hot solution of TBZ (1000ppm) at 52°C for 5 min.; Ca=soaking in Calcium chloride 8% for 15 min.;

resulted in the 5th to the 7th week of cold storage without significant differences between them in both seasons. The least pH values resulted in the 4th week in both seasons. The differences between pH values in the 4th and 5th weeks of cold storage periods were insignificant in both seasons.

The interaction (Period × Treatment) was insignificant in both seasons.

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تأثير كل من كلوريد الكالسيوم و بعض المعاملات الأخرى بعد الحصاد على صفات الجودة فى ثمار المانجو العويس أثناء و بعد التخزين المبرد

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أجريت هذه الدراسة في عامى ١٩٩٦ ،١٩٩٧ حيث عوملت ثمار المانجو العويس المقطوفة فى مرحلة إكتمال النمو أو بعد بدء تغيرات النضج بأحد المعاملات الخمس التالية : (١) نقع الثمار مكتملة النمو فى محلول ثيوبندازول ١٠٠٠ جزء فى المليون لمدة خمس دقائق ثم التعبئة فى أكياس بولى إيثيلين مثقبة (٠,٢٥% من مساحة الكيس) ، (٢) كما فى رقم (١) و لكن بعد نقع الثمار مكتملة النمو فى الثيوبندازول و قبل التعبئة فى أكياس البولى إيثيلين يتم نقع الثمار فى محلول كلوريد الكالسيوم بتركيز ٨% لمدة ١٥ دقيقة ، (٣) كما فى الخطوة رقم (١) ولكن على ثمار فى مرحلة بدء النضج ، (٤) كما فى الخطوة رقم (٢) و لكن على ثمار فى مرحلة بدء النضج ، (٥) تم نقع الثمار فى مرحلة بدء النضج فى ثيوبندازول ١٠٠٠ جزء في المليون على درجة حرارة ٥٢°م لمدة ٥ دقائق بعد ذلك تم نقع الثمار في محلول كلوريد الكالسيوم ٨% لمدة ١٥ دقيقة ثم تمت التعبئة فى أكياس بولى إيثيلين محكمة الغلق. ثم تم تخزين الثمار مكتملة النمو المعاملة عند درجة حرارة ١٣±١°م ، بينما الثمار المعاملة فى مرحلة بدء النضج عند درجة حرارة ٨±١°م لمدة ٧ أسابيع . و قد تم أخذ عينات إسبوعية لتقييم تأثير المعاملات و فترة التخزين البارد على الثمار. علاوة على ذلك ، مع بداية الاسبوع الثالث من التخزين البارد ، تم أخذ عينات من الثمار و حفظها على أرفف لمدة خمس أيام فى ظروف تماثل السوبر ماركت (٢٠°م ،٦٠-٧٠% رطوبة نسبية) . لملاحظة تأثير ذلك على خواص الثمار.

تظهر النتائج بصفة عامة، إرتفاع القدرة التخزينية للثمار فى بداية مرحلة النضج بالمقارنة بالثمار مكتملة النمو. بالإضافة إلى ذلك، فقد أمكن الحصول على أفضل النتائج الواعدة بمعاملة الثمار فى بدء مرحلة النضج بواسطة الثيوبندازول ١٠٠٠ جزء فى المليون لمدة خمس دقائق، ثم النقع فى محلول كلوريد الكالسيوم بتركيز ٨% لمدة خمسة عشرة دقيقة ، ثم التعبئة فى أكياس بولى إيثيلين مثقبة بنسبة ٠,٢٥%، و التخزين لمدة خمسة أسابيع على درجة حرارة ٨°م . و قد أوضحت ثمار هذه المعاملة أقل فقد فى الوزن الطازج للثمار و أقل تلف و تلوين ، بينما كان هناك إرتفاع نسبى فى صلابة الثمار و درجة إختبار التحكيم الشخصى و النسبة المئوية للمواد الصلبة الذائبة الكلية بالمقارنة بالمعاملات المختبرة الأخرى.