Journal of Horticultural Science & Ornamental Plants 4 (1): 07-17, 2012
ISSN 2079-2158

Effects of Polyolefin Film Wrapping and Calcium Chloride Treatments on Posthravest Quality of "Wonderful" Pomegranate Fruits

[1]Nazmy A. Abd-elghany, [2]Samah I. Nasr and [3]Hassan. M. Korkar

[1]Horticulture Department, Faculty of Agriculture Ain Shams University, Egypt
[2]Ministry of Agriculture, Egypt
[3]Higher Institute for Agriculture Co-Operation, Cairo, Egypt

Abstract: Pomegranate (*Punica granatum* L.) fruits are very susceptible to chilling injury during cold storage. So, this experiment was conducted during two successive season of 2010 and 2011 to test the effects of polyolefin film wrapping and calcium chloride treatments on postharvest quality of 'Wonderful' pomegranates. Fruits were harvested at mature ripe stage and washed before applying the treatments. Fruits were dipped in 0%, 2% or 3% Calcium chloride solution for 4 min. alone or in combination with polyolefin films wrapped. The treated fruits were air – dried at 24±1°C and stored at 5±1°C with 85 ±5 % RH for 2 months subsequent 2 weeks on marketing conditions at 20± 2°C. Changes in weight loss, firmness, peel thickness, total soluble solids (TSS), L- ascorbic acid content, titratable acidity (TA), Respiration rate and sensory quality were retained. Weight loss and respiration rate greatly reduced by all wrapped fruits than non-wrapped fruits the same period. Fruits treated with 2% Calcium chloride combination with films wrapped retained maximum firmness, peel thickness, L- ascorbic acid and sensory quality and minimum acidity and discarded fruits. Changes in pigment anthocyanins and TSS values showed no statistical differences among treatments at any storage temperature.

Key words: Pomegranate · Films wrapping · Cold Storage · Respiration rate · Calcium chloride · Market conditions

INTRODUCTION

Pomegranate (*Punica granatum* L.) is an important fruit crop of many tropical and subtropical regions of the world, grown especially in the moderate climates of Mediterranean countries. As production has increased, proper storage and marketing of these fruits is needed to meet the demand both in domestic and export markets. The fruits are generally harvested fully ripe with a waxy shining surface of reddish yellow or greenish red peel color, depending on the cultivar. The major storage problem is desiccation of the fruit resulting in a brownish colored tough peel and browning of arils. Although the peel appears to be thick, it has numerous minute openings that permit free movement of water vapour, making the fruit highly susceptible to water loss [1, 2]. Further, the storage temperature recommended for pomegranates has varied from 0 to 10°C with a shelf life ranging from 2 weeks to 7 months depending on the cultivar [1, 3-6].

Calcium (Ca^{2+}) has been extensively reviewed as both an essential element and its potential role in maintaining postharvest quality of fruit and vegetable crops by contributing to the linkages between pectic substances within the cell-wall [7-9]. The presence of Ca^{2+} ions increases the cohesion of cell-walls [10, 11]. It is also involved in reducing the rate of senescence and fruit ripening [12-14]. A 1% solution of $CaCl_2$ delayed fruit ripening, improved resistance to fungal attack and maintained structural integrity of cell walls of strawberry during a 10 day storage period at 3°C [10]. Moreover, softening was delayed and storage life was increased by 10–12 weeks in Kiwi fruits stored at 0°C by application of 1% $CaCl_2$ compared with untreated fruit [15, 8]. Storing pomegranate at 2°C with 4 % $CaCl_2$ minimized chilling injury and maintained fruit quality for up to 13 weeks [16]. Keeping in view the usefulness of $CaCl_2$ treatments in fruits as revealed by various scientists.

Correspoding Author: Nazmy A.Horticulture Department, Faculty of Agriculture Ain Shams University, Egypt.

Individual film wrapping of fresh fruits and vegetables will greatly reduce weight loss by reducing the transpiration rate and maintain fruit firmness [17-18]. But no work on shrink wrapping of pomegranates has been reported so far. Edible sucrose polyesters (SPE) have been applied successfully as coatings to extend the postharvest life of fresh fruits such as apples, banana, limes, mangoes, oranges, pomegranate and Peach [19-27]. Wonderful' pomegranate has long been the major supplier. A late producer with high yields, the large fruit has deep red flesh that is high in juice with a slightly acid taste [28, 29].

The present study was aimed to evaluate the effectiveness of postharvest immersion of different $CaCl_2$ concentrations and films wrapping on the postharvest quality attributes of "Wonderful" Pomegranate fruit during cold storage for short time (2 month) representing the shipment and transport conditions during handling and export of the fruits and market conditions.

MATERIALS AND METHODS

Fully mature, medium size (350–400 g) pomegranate fruits (cv. Wonderful) were harvested early August from different trees of a commercial orchard at El_Ghazoo Agriculture Society near Dina Farms,Giza Governorate during 2010 and 2011 seasons and brought to the postharvest laboratory at the Department of Horticulture, Ain Shames University on the same day. The maturity of the fruit was judged by the development of shiny red peel color, full opening of the calyx and deep red colored juicy arils. Diseased, bruised and injured fruits were rejected and sound fruit of uniform size and appearance were randomly distributed into different lots. The fruit were clipped and washed with distilled water to remove any dirt and dipped in 0%, 2% or 3% Calcium chloride ($CaCl_2$) solution for 4 min alone or in combination with polyolefin films wrapped.

The fruit were wrapped individually using heat-shrinkable films BDF-2001 (a multi-layered co-extruded polyolefin film), film was 25 mm thick. The fruits were sealed in the above films using an L-bar sealer (Weldotron model 6300-L) and then heat-shrunk by passing them through a heat-shrink tunnel (Weldotron model 7121A, Weldotron Corporation, NJ) for 10–15 s at 300– 350°F. The short time exposure of the fruit to the high temperature in the heat tunnel did not adversely affect the peel color of the pomegranates. Film wrapping Permeability of CO_2 33.000 and O_2 8.000 (cm^3/m^2/24 hr bar at 23 C 0% RH) Water vapor transmission rate. 12 (g/m^2/24 hr bar at 38°C 90% RH)

The Used Treatments Were:

- Control (0% $CaCl_2$ and on wrapping)
- Polyolefin films wrapped (B.D.F.)
- 2 % $CaCl_2$ solution
- 4 % $CaCl_2$ solution
- 2 % $CaCl_2$ solution + B.D.F.
- 4% $CaCl_2$ solution + B.D.F.

Each treatment included thirtieth fruits and was replicated three times. Fruits were packed in export cartons boxes and stored at 5±1°C with 85 ±5 % RH in the cold store for 2 months subsequent 2 weeks representing market conditions at 20± 2°C.

A sample of randomly selected fruits at the beginning of cold storage duration (0 day) and bimonthly (15 days) intervals was collected from each replication for all treatments during the storage period and weekly during market conditions 20±2°C. Data on the following parameters was recorded.

Fruit Physical Analysis

Weight Loss (%): To evaluate weight loss, separate samples in 3 replicates of each treatment were used. The same samples were evaluated for weight loss by the following formula:

$$\text{Weight loss (\%)} = [(A-B)/A] \times 100$$

- A indicates the fruit weight at the beginning time of storage(initial weight loss)
- B indicates the fruit weight after storage intervals.

Discarded fruits (%): Fruit showed any sign of decay or visual disorders were counted.The percentage of discarded fruits were calculated on the bases of total fruit number using the following formula:

$$\text{Discarded fruits \%} = \frac{\text{Number of discarded fruits at each sampling date}}{\text{Total number of fruits}} \times 100$$

Fruit firmness (Kg f): Fruit firmness was determined by peeling the fruit at two equatorial sites and measuring firmness by means of a Wagner® Fruit Firmness Tester, model FT-327, equipped with an 8mm plunger tip. Values were expressed in kilo gram force (kgf).

Sensory Quality: Sensory quality for freshness, aril color, juiciness and flavour of fruits was evaluated by a panel of eight assessors at the end of market condition. The evaluation was done on a scale of 1–5, where 5_very

good (like very much with harvest freshness, bright pink juicy arils and without any off flavour) and 1_ very bad (dislike completely with desiccated fruits with brown tough peel, brown color arils with low juiciness and becoming dry). Scores of 3 (like moderately with retention of freshness, color and juiciness of arils) and above were considered acceptable for commercial purposes [26].

Fruit Chemical Analysis:

Total Soluble Solid: Total soluble solids (TSS) was measured by the refractive index expressed as°Brix with an Erma hand refractometer (reading at 20°C) [30].

Titratable Acidity: Pulp of (10g) was homogenized in 40 ml distilled water and filtered to extract the juice. Two to five drops of phenolphthalein was added in this juice. A 10 ml aliquot was taken in a titration flask and titrated against 0.1N NaOH till permanent light pink color appeared. Three consecutive readings were taken from each replication of a treatment and acidity percent as malic acid was calculated according to A.O.A.C. [30].

Ascorbic Acid Content (mg/100g F.wt): The L-ascorbic acid content (V.C) was determined and expressed as mg/100 g fresh weight using 10 g. of the fruit tissues were homogenized in 100 ml of 3% oxalic acid, the extraction was filtered and 10 ml was titrated against 2,6-dichlo phenolendo phenol dye and ascorbic acid was calculated according to A.O.A.C. [30].

Respiration Rate (mg CO_2/kg Fruit/hr): Carbon dioxide produced by pomegranate fruits was determined after 10 hrs finished from treatments and then every 15 days during cold storage and 7 days the subsequent storage at 20±2°C. until experiment termination. The air-flow was passed through concentrated NaOH, to insure that air-flow is CO_2 free, before passing into 1-liter jar fruit container (fruit ambient) one fruit/jar was considered as one replicate. The out-coming air-flow was then passed into 100 ml NaOH of 0.1 N for 1 h. Such solution was then titrated against 0.1 N HCl and CO_2 levels produced by the fruits were then calculated as mg CO_2/kg fruits/h [31].

Pigment Anthocyanins Content (mg/100g F.wt): Total anthocyanins was extracted from one gram pulp fresh weight with 100 mm. 0.1% methanolic HCL, the solution filtered and absorbency measured at 520 nm on Spekol 11 spectrophotometer [32].

Statistical Analysis: The experiment was a completely randomized design (CRD) with factorial arrangement. Comparison between means was evaluated by Duncan's Multiple Range Test at 5% level of significance. All storage treatments were done with three replications according to Sendecor and Cochran [33].

RESULTS AND DISCUSSION

Fruit Physical Analysis

Weight Loss: Data in Table 1 showed that, weight loss % (of the first season) ranged from 0.89 to 2.38 with different treatments at the beginning of cold storage. Polyolefin wrapping of pomegranates greatly reduced weight loss during storage at different duration. After 60 days of cold storage, the fruit lost only 2.16, 2.23 and 2.10 % of weight when wrapped alone or with treated both concentrations of $CaCl_2$ (2 and 4%) as compared to 7.05, 4.02 and 3.90% in non-wrapped fruits and dipped in $CaCl_2$ 2 or 4% alone respectively (data of first season). Data of second season was followed the same trend obtained in first one. Reduction in weight loss by shrink wrapping was also reported by Hale *et al*. [34] on Florida grapefruit, Ladaniya *et al*. [35] in 'Nagpur' mandarins and Nanda *et al*. [26] on pomegranates.

With advanced in storage duration (the end of market duration) maximum weight loss occurred in control (11.82%) while lowest loss (5.55%) was recorded in 2% $CaCl_2$ combination with polyolefin films wrapped. Calcium applications have known to be effective in terms of membrane functionality and integrity maintenance which may be the reason for the lower weight loss found in calcium treated fruits. Lester and Grusak [36] and Mahajan and Dhatt [14] reported that, pear fruit treated with $CaCl_2$ proved to be most effective in reducing weight loss compared to non treated fruit during a 75 days storage period.

Discarded Fruits (%): An evident increase in discarded fruits % with prolonging the days in storage duration irrespective of the used treatments (Table, 2). The treatment of control recorded the highest percentage of discarded fruits followed by the dipped fruit with 2 or 4% $CaCl_2$ which give the moderate values (10.0, 6.67 and 13.33, 16.67 %) in the first season and (13.33, 6.67 and 20.0, 13.33%) in the second season during the end of cold storage and the end of market conditions respectively. On the other hand, wrapped fruit with polyolefin film

Table 1: Effects of polyolefin film wrapping and calcium chloride treatments on weight loss % of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)				Days at (20±2°)C	
Treatments	15	30	45	60	7	14
			Season 2010			
Control	2.38 a	3.36 a	5.31 a	7.05 a	8.15 a	11.82a
B.D.F.	0.78 c	1.38cd	1.69 c	2.16 c	4.22 c	6.67cd
2 % $CaCl_2$	1.56 b	2.12 b	3.17 b	4.02 b	5.00bc	8.20 b
4 % $CaCl_2$	1.34 b	1.98bc	2.56bc	3.90 b	5.88 b	8.64 b
2 % $CaCl_2$ + B.D.F	0.83 c	1.15 d	1.71 c	2.23 c	4.14 c	5.55 d
4% $CaCl_2$ + B.D.F	0.89 c	1.21 d	1.80 c	2.10 c	4.07 c	6.60cd
			Season 2011			
Control	2.50	3.12	5.16	7.29	8.80	10.02
B.D.F	0.67	1.27	1.83	2.29	3.89	6.36
2 % $CaCl_2$	1.81	2.25	3.35	4.52	5.33	7.75
4 % $CaCl_2$	1.16	2.02	2.80	3.91	6.02	8.50
2 % $CaCl_2$ + B.D.F	0.87	1.23	2.07	2.67	3.99	5.69
4% $CaCl_2$ + B.D.F	0.96	1.55	2.11	2.87	3.90	6.11

Values followed by the same letter (s) are not significantly different at 5% level

B.D.F: Fruit wrapped with polyolefin films.

2 % $CaCl_2$ +: B.D.F. Fruit treated with 2 % $CaCl_2$ and wrapped with polyolefin films.

4 % $CaCl_2$ +. B.D.F Fruit treated with 4 % $CaCl_2$ and wrapped with polyolefin films.

Table 2: Effects of polyolefin film wrapping and calcium chloride treatments on discarded fruits % of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)				Days at (20±2°)C	
Treatments	15	30	45	60	7	14
			Season 2010			
Control	--	--	6.67 a	16.67 a	26.67a	36.67 a
B.D.F	--	--	--	3.33c	6.67 bc	6.67c
2 % $CaCl_2$	--	--	3.33 a	10.0 b	10.0 b	13.33 bc
4 % $CaCl_2$	--	--	3.33 a	6.67 b	13.33 b	16.67 b
2 % $CaCl_2$ +B.D.F.	--	--	--	--	--	--
4% $CaCl_2$ + B.D.F.	--	--	--	--	3.33c	6.67 c
			Season 2011			
Control	--	--	13.33 a	20.0 a	33.33 a	43.33 a
B.D.F.	--	--	--	--	6.67 b	13.33 bc
2 % $CaCl_2$	--	--	--	13.33 a	13.33 b	20.0 b
4 % $CaCl_2$	--	--	--	--	6.67 b	13.33 bc
2 % $CaCl_2$ +B.D.F.	--	--	--	--	--	--
4% $CaCl_2$ + B.D.F.	--	--	--	--	--	10.0 c

See footnote of Table 1.

alone or combination with 4 % calcium application recorded slight values (6.67, 6.67 % and 13.33, 10.0%) in the end of storage at 20°C during the two studied seasons respectively. Did not show any discarded fruits with treated wrapped fruits by %2calcium chloride fruits.

Fruit Firmness: No significant differences were noticed between different treatments on fruit firmness for initial sample even 30 days of cold storage where it was ranged from 12.7 to 10.9 kilo gram force in the first season and ranged from 13.8 to 11.2 kilo gram force in the second season. However, during storage duration the differences appeared, the end of market conditions a sharp decrease in fruit firmness were noticed with control treatment (6.0 and 7.1 kgf) in the both season (Table 3). Moreover higher fruit firmness values (10.3 and 10.0 kgf) were recorded with treated wrapped fruits with 2% $CaCl_2$ during 2010 and 2011 respectively. Similar results on maintenance of firmness by shrink wrapping were recorded for many fruits and vegetables including, lemons, pomegranate and peppers [18, 37, 26].

Table 3: Effects of polyolefin film wrapping and calcium chloride treatments on fruit firmness (kgf) of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)					Days at (20±2°C)	
Treatments	0	15	30	45	60	7	14
			Season 2010				
Control	12.6 a	11.7 a	10.9 a	9.4 c	8.0 c	6.7 c	6.0 d
B.D.F	12.4 a	12.2 a	11.3 a	10.7 b	10.4 b	10.0 ab	9.6 b
2 % $CaCl_2$	12.1 a	12.4 a	11.7 a	10.5 b	10.0 b	9.3 b	8.8 bc
4 % $CaCl_2$	12.5 a	12.0 a	11.1 a	10.7 b	10.4 b	9.5 b	8.2 c
B.D.F. + 2 % $CaCl_2$	12.5 a	12.4 a	12.0 a	11.8 a	11.3 a	10.6 a	10.3 a
B.D.F. + 4% $CaCl_2$	12.7 a	12.0 a	11.5 a	11.2 ab	10.6 ab	9.6 b	8.2 c
			Season 2011				
Control	13.8 a	12.7 a	11.3 a	10.2 c	9.3 c	7.4 d	7.1 d
B.D.F	13.3 a	12.5 a	11.2 a	10.7 b	10.3 b	9.9 b	9.1 b
2 % $CaCl_2$	13.5 a	12.7 a	11.4 a	11.1 ab	10.5 b	9.3 c	8.4 c
4 % $CaCl_2$	13.6 a	12.5 a	11.4 a	10.9 b	10.6 b	9.7 b	8.7 c
B.D.F. + 2 % $CaCl_2$	13.8 a	12.6 a	11.9 a	11.5 a	11.1 a	10.8 a	10.0 a
B.D.F. + 4% $CaCl_2$	13.4 a	12.5 a	12.1 a	11.4 a	11.2 a	10.5 a	9.3 b

See footnote of Table 1.

Table 4: Effects of polyolefin film wrapping and calcium chloride treatments on peel thickness (cm) of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)					Days at (20±2°C)	
Treatments	0	15	30	45	60	7	14
			Season 2010				
Control	0.40 a	0.35 a	0.30 b	0.27 b	0.22 c	0.18 d	0.16 c
B.D.F	0.39 a	0.37 a	0.35 ab	0.33 a	0.30 ab	0.26 bc	0.25 ab
2 % $CaCl_2$	0.40 a	0.37 a	0.30 b	0.29 ab	0.27 b	0.23 c	0.22 b
4 % $CaCl_2$	0.39 a	0.37 a	0.32 ab	0.29 ab	0.30 ab	0.28 b	0.21 b
B.D.F. + 2 % $CaCl_2$	0.39 a	0.38 a	0.36 a	0.34 a	0.33 a	0.32 a	0.28 a
B.D.F. + 4% $CaCl_2$	0.37 a	0.37 a	0.35 ab	0.32 ab	0.31 a	0.28 b	0.27 a
			Season 2011				
Control	0.44 a	0.38 a	0.33 b	0..30 b	0.26 c	0.20 c	0.18 c
B.D.F	0.42 a	0.40 a	0.37 a	0.35 ab	0.31 ab	0.28 ab	0.27 a
2 % $CaCl_2$	0.45 a	0.39 a	0.36 ab	0.32 ab	0.29 bc	0.26 b	0.24 b
4 % $CaCl_2$	0.45 a	0.39 a	0.35 ab	0.33 ab	0.30 ab	0.27 b	0.23 b
B.D.F. + 2 % $CaCl_2$	0.42 a	0.40 a	0.38 a	0.37 a	0.34 a	0.32 a	0.30 a
B.D.F. + 4% $CaCl_2$	0.41 a	0.39 a	0.38 a	0.36 a	0.33 a	0.30 a	0.26 ab

See footnote of Table 1.

Table 5: Effects of polyolefin film wrapping and calcium chloride treatments on sensory evaluation of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Season 2010				Season 2011			
	The end of market condition				The end of market condition			
Treatment	Freshness	Aril color	Taste	Juiciness	Freshness	Aril color	Taste	Juiciness
Control	1.8 d	2.7 c	2.7 c	2.2 c	1.6 d	2.8 c	2.5 c	2.4 c
B.D.F	3.6 ab	3.5 ab	3.6 b	3.7 a	3.4 b	3.6 b	3.3 b	3.8 a
2 % $CaCl_2$	3.0 bc	3.3 b	3.3 b	2.8 b	3.0 bc	3.2 bc	3.1 b	3.1 b
4 % $CaCl_2$	2.6 bc	3.4 ab	3.3 b	3.0 b	2.7 c	3.2 bc	3.2 b	3.1 b
B.D.F. + 2 % $CaCl_2$	4.0 a	4.0 a	4.2 a	3.9 a	4.0 a	4.4 a	4.3 a	3.7 a
B.D.F. + 4% $CaCl_2$	3.2 b	3.8 a	3.8 ab	3.7 a	3.3 b	3.6 b	3.9 a	3.8 a

See footnote of Table 1

The retention of firmness in calcium treated fruits might be due its accumulation in the cell walls leading to facilitation in the cross linking of the pectic polymers which increases wall strength and cell cohesion [13]. These results are also in accordance with those reported by Shuiliang *et al*. [38] and Arhtar *et al*. [8].

Peel Thickness: It was noticed that, peel thickness of pomegranates decreased with increasing storage durations. The decrease in peel thickness was significantly higher with control treatment than other treatments. Appeared peel thickness of untreated pomegranates (30 & 22 and 33 & 26 mm) after 30 and 60 days during 2010 and 2011 season respectively of cold storage. Meanwhile treated warped fruits with both concentrations of calcium chloride recorded significantly higher values after 30 as well as 60 days of cold storage (Table 4). Slight differences were noticed with wrapped or dipped fruit only which showed moderate values ??ranged between (27 -30 and 19 – 31 mm) after 60 days of cold storage in the both seasons under studied respectively. The same direction the treatments as found at the end of the market conditions at 20°C.

Sensory Evaluation: It is clear from data in (Table 5) that, sensory evaluation greatly affected with some pre storage treatments of pomegranate fruits.However the wrapped fruits combination with 2% calcium chloride got high scores for aril color, juiciness and taste during sensory evaluation compared with non-wrapped and treated fruits with both concentrations of $CaCl_2$ which achieved values moderate without significant differences between them. The wrapped fruits alone exhibited the better scores for appearance which were fresh with bright yellowish red rind color and secured. Whereas non-wrapped fruits exhibited unmarketable, sensory evaluation i,e: desiccated fruits with brown tough peel, brown color arils, low juiciness and becoming dry.

Fruit Chemical Analysis

Total Soluble Solid: A slight increase in total soluble solid contents in pomegranate fruit was recorded with the used treatments and control with advanced in cold storage at 5°C and market conditions at 20°C (Table 6). No significant differences in the total soluble solid content due to treatments were recorded. Non-treated fruits exhibited less significantly values (16.0, 14.1 and 16.4, 15.1 %) ??after 60 days at cold storage and the end of market conditions during the both tested seasons.

Titratable Acidity: As for first season, generally, titratable acidity decrease gradually in all used treatments with advanced in cold storage and market conditions. No significant differences in fruit acidity with different treatments during cold storage at 5°C till 60 days except control treatment where it decreased till 30 days and then increased to the end of cold storage reached to (1.73%). This might be due to, higher of respiration rate in untreated fruits as compared to reduced rate in treated fruits. The differences in fruit acidity were noticed with the end of market conditions at 20°C especially with treated fruits at 2% calcium chloride which recorded less significant value (1.12%) followed by wrapped fruits with or without calcium chloride at 2 or 4% (1.16, 1.22and 1.23%) respectively with slight differences among them (Table 7). On the contrast untreated fruits achieved the high significant value (1.82%) of acidity. Regarding the second season, the obtained results were similar to those found in the first one. As pomegranate is a nonclimacteric fruit, loss in acid occurred with ongoing

Table 6: Effects of polyolefin film wrapping and calcium chloride treatments on total soluble solid(TSS) of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)					Days at (20±2°C)	
Treatments	0	15	30	45	60	7	14
				Season 2010			
Control	16.6 a	16.7 a	16.8 a	16.3 a	16.0 b	15.3 b	14.1 b
B.D.F	16.5 a	16.8 a	16.7 a	16.9 a	17.0 a	17.2 a	17.4 a
2 % $CaCl_2$	16.4 a	16.8 a	16.8 a	17.2 a	17.7 a	17.5 a	17.5 a
4 % $CaCl_2$	16.6 a	16.6 a	17.0 a	17.0 a	17.2 a	17.3 a	17.5 a
B.D.F. + 2 % $CaCl_2$	16.4 a	16.5 a	16.8 a	17.0 a	17.3 a	17.7 a	17.8 a
B.D.F. + 4% $CaCl_2$	16.4 a	16.5 a	16.7 a	17.3 a	17.5 a	17.5 a	17.5 a
				Season 2011			
Control	16.8 a	16.9 a	17.0 a	16.7 b	16.4 b	15.9 b	15.1 b
B.D.F	16.7 a	16.9 a	17.1 a	17.0 ab	17.3 a	17.4 a	17.4 a
2 % $CaCl_2$	16.9 a	17.0 a	17.1 a	17.3 a	17.5 a	17.4 a	17.4 a
4 % $CaCl_2$	16.8 a	17.0 a	17.3 a	17.3 a	17.4 a	17.3 a	17.6 a
B.D.F. + 2 % $CaCl_2$	16.9 a	16.8 a	17.2 a	17.4 a	17.5 a	17.5 a	17.6 a
B.D.F. + 4% $CaCl_2$	16.8 a	17.1 a	17.3 a	17.4 a	17.5 a	17.3 a	17.5 a

See footnote of Table 1.

Table 7: Effects of polyolefin film wrapping and calcium chloride treatments on titratable acidity (TA) of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)					Days at (20±2°C)	
Treatments	0	15	30	45	60	7	14
			Season 2010				
Control	1.71 a	1.68 a	1.62 a	1.69 a	1.73 a	1.77 a	1.82 a
B.D.F	1.69 a	1.60 a	1.55 a	1.50 b	1.38 b	1.30 b	1.23 bc
2 % $CaCl_2$	1.70 a	1.57 a	1.52 a	1.34 b	1.24 b	1.19 b	1.12 c
4 % $CaCl_2$	1.70 a	1.58 a	1.53 a	1.35 b	1.30 b	1.24 b	1.26 b
B.D.F. + 2 % $CaCl_2$	1.70 a	1.63 a	1.57 a	1.37 b	1.32 b	1.20 b	1.16 bc
B.D.F. + 4% $CaCl_2$	1.67 a	1.60 a	1.50 a	1.36 b	1.33 b	1.25 b	1.22 bc
			Season 2011				
Control	1.79 a	1.74 a	1.69 a	1.68 a	1.70 a	1.79 a	1.81 a
B.D.F	1.81 a	1.73 a	167 a	1.55 b	1.43 b	1.32 b	1.25 b
2 % $CaCl_2$	1.78 a	1.75 a	1.69 a	1.57 b	1.41 b	1.35 b	1.19 b
4 % $CaCl_2$	1.80 a	1.71 a	1.66 a	1.59 b	1.37 b	1.34 b	1.20 b
B.D.F. + 2 % $CaCl_2$	1.80 a	1.72 a	1.65 a	1.54 b	1.42 b	1.33 b	1.17 b
B.D.F. + 4% $CaCl_2$	1.79 a	1.72 a	1.68 a	1.52 b	1.44 b	1.34 b	1.21 b

See footnote of Table 1.

Table 8: Effects of polyolefin film wrapping and calcium chloride treatments on ascorbic acid content (mg/100g F.wt) of pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

	Days in cold storage (5±1°C)					Days at (20±2°C)	
Treatments	0	15	30	45	60	7	14
			Season 2010				
Control	96.8 a	90.4 a	81.2 b	76.0 c	70.2 c	64.6 c	55.9 c
B.D.F	95.4 a	91.6 a	85.9 b	80.6 b	75.6 b	70.4 b	65.8 ab
2 % $CaCl_2$	93.5 a	94.4 a	87.4 a	81.7 bc	77.2 ab	71.9 ab	63.9 b
4 % $CaCl_2$	95.5 a	91.5 a	88.1 a	84.7 ab	76.4 ab	70.0 b	62.7 b
B.D.F. + 2 % $CaCl_2$	94.5 a	93.5 a	90.2 a	86.0 a	80.2 a	74.5 a	69.5 a
B.D.F. + 4% $CaCl_2$	95.0 a	93.4 a	87.6 a	82.4 ab	79.8 a	72.0 ab	67.0 a
			Season 2011				
Control	88.7 a	83.2 a	73.9 b	71.8 b	64.7 c	60.4 c	54.0 c
B.D.F	84.6 a	84.1 a	79.4 a	75.5 a	70.0 ab	65.4 b	62.7 ab
2 % $CaCl_2$	86.4 a	84.2 a	78.4 a	73.1 ab	68.4 b	65.0 b	60.4 b
4 % $CaCl_2$	85.9 a	82.5 a	76.8 ab	75.9 a	68.8 b	64.7 b	61.1 ab
B.D.F. + 2 % $CaCl_2$	86.7 a	82.2 a	76.4 ab	74.6 ab	72.4 a	68.8 a	63.5 a
B.D.F. + 4% $CaCl_2$	87.1 a	80.9 a	78.8 a	75.0 a	70.1 ab	66.1 ab	64.0 a

See footnote of Table 1.76.9

Table 9: Effects of polyolefin film wrapping and calcium chloride treatments on pigment anthocyanins (mg/100g F.wt) of "Wonderful" pomegranate fruit during cold storage at 5°C and market conditions at 20°C. during 2010 and 2011 seasons

	Days in cold storage (5±1°C)					Days at (20±2°C)	
Treatments	0	15	30	45	60	7	14
			Season 2010				
Control	0.46 a	0.44 a	0.38 a	0.35 a	0.30 b	0.27 b	0.22 b
B.D.F	0.44 a	0.42 a	0.40 a	0.37 a	0.36 a	0.34 a	0.32 a
2 % $CaCl_2$	0.44 a	0.41 a	0.40 a	0.38 a	0.35 a	0.33 a	0.32 a
4 % $CaCl_2$	0.46 a	0.42 a	0.42 a	0.40 a	0.35 a	0.33 a	0.32 a
B.D.F. + 2 % $CaCl_2$	0.45 a	0.43 a	0.43 a	0.41 a	0.38 a	0.35 a	0.34 a
B.D.F. + 4% $CaCl_2$	0.45 a	0.44 a	0.41 a	0.38 a	0.37 a	0.36 a	0.34 a
			Season 2011				
Control	0.46 a	0.42 a	0.37 a	0.34 b	0.30 b	0.26 b	0.24 b
B.D.F	0.48 a	0.44 a	0.40 a	0..39 a	0.37 a	0.34 a	0.30 a
2 % $CaCl_2$	0.48 a	0.45 a	0.42 a	0.37 ab	0.35 a	0.33 a	0.31 a
4 % $CaCl_2$	0.47 a	0.45 a	0.40 a	0.38 a	0.35 a	0.35 a	0.32 a
B.D.F. + 2 % $CaCl_2$	0.46 a	0.46 a	0.41 a	0.37 ab	0.36 a	0.34 a	0.32 a
B.D.F. + 4% $CaCl_2$	0.46 a	0.44 a	0.42 a	0.36 ab	0.37 a	0.34 a	0.31 a

See footnote of Table 1.

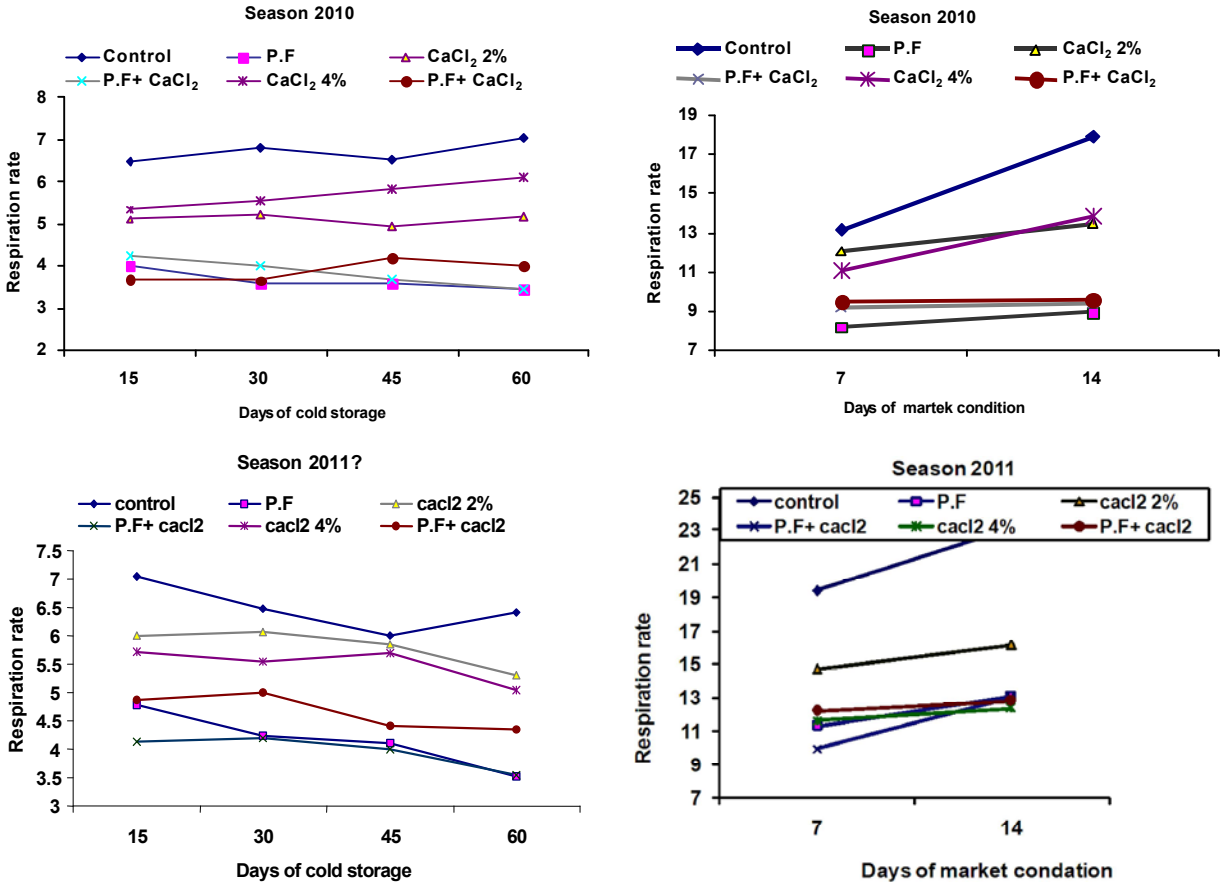

Fig. 1: Effects of polyolefin film wrapping and calcium chloride treatments on respiration rate of pomegranate fruit during cold storage at 5°C and market conditions at 20°C during 2010 and 2011 seasons

metabolism, in agreement with those found by Kader *et al*. [1] on 'Wonderful'; Arhtar *et al.* Artes [2] on Mollar' and Nanda *et al*. [26] on different cultivars of pomegranate. The loss in acid values is largely due to the utilization of organic acid as respiratory substrates and as carbon skeleton for the synthesis of new compounds during ripening. Also accumulation of sugars during contributes to decrease of acidity as result of increase in TSS acid ratio [39].

Ascorbic Acid Content: L-ascorbic acid content was decreased gradually with advanced in cold storage durations in treated or untreated fruits (Table 8). This finding could be attributed to the conversion of L-ascorbic acid to dehydroascorbic acid and decreasing the active form of ascorbic. No significant differences were noticed between different treatments and controls till 15 days of cold storage. Untreated fruit exhibited the least value of L-ascorbic than all treatments. Low temperature storage caused a decline in ascorbic acid content. The reduction in L-ascorbic in the untreated fruits ranged from 96.8 mg to 55.9 mg/100 g fresh weight (about 42.3% losses in L-ascorbic acid). This finding is correlated to the previously mentioned about acidity and T.S.S where these fruits recorded less fruit quality characters. On contrary, the high L-ascorbic acid values were found with wrapped fruits alone or in combination with 2% and 4% $CaCl_2$, the reduction in L-ascorbic acid content in these treatments ranged from 94.4-65.8 mg(30.2%) & 94.5 to 69.5 mg (26.4%) and from 95.0 to 67.0 mg (29.4%) respectively.The same trend of results was noticed in the two studied seasons. Ascorbic acid is an important nutrient quality parameter and is very sensitive to degradation due to its oxidation compared to other nutrients during food processing and storage [40]. Higher concentrations of $CaCl_2$ delayed the rapid oxidation of ascorbic acid [41, 8].

Respiration Rate (mg CO_2/kg fruit/hr): Pomegranate fruits had a relatively low respiration rate, which declined with time after harvest (Fig. 1). Koksal [4] and Artes *et al*. [2] also noted a constant decline in respiration rate of pomegranates during storage. Shrink wrapping of our study significantly reduced the respiration rate, possibly due to the low permeability of the films used for wrapping. Individual seal wrapping has also been reported to reduce the respiration rate of 'Nagpur' mandarins by 47% as compared with unwrapped fruits at 30°C storage [40, 26]. No significant differences between the fruit treated with $CaCl_2$ at 2or 4% which achieved moderated values of respiration rate during cold storage and under marketing conditions.

Calcium content in the harvest fruit plays also vitals roles in ethylene fruit, action and respiration [41, 27]. The well established correlation between Ca content of fruit and their respiration after harvest can also be explained in part by altered membrane permeability. In this case Ca may reduce endogenous substrate cabalism by limiting the diffusion of substrate from the vacuole to the respiratory enzymes in the cytoplasm [42].

CO2 was within the range from (3.45 to 7.10 mg CO2/kg fruit/hr) during cold storage and from (8.18 to 17.89 mg CO2/kg fruit/hr) during market conditions.Changes in respiration rate for pomegranate under both cold storage and market conditions were significant.

Pigment Anthocyanins: It is clear that, anthocyanins content was decreased gradually within storage in treated or untreated fruits (Table 9). Slightly changed were observed during the two storage at (5 and 20°C) among all used treatments However, untreated fruit recorded the lest values of anthocyanins content which give 0.30 and 0.22 mg/100g F.wt compared to (0.38 and 0.34 mg/100g F.wt) with wrapped fruit + dipped 2% $CaCl_2$ the end of cold storage and at the end of marketing respectively. The same trend of results was also, obtained in the second season Gil *et al*. [5] found no significant differences in juice color of pomegranate fruit kept at 5°C up to 6 weeks.

From the obtained data, it could be concluded that "Wonderful " pomegranate fruits wrapped with edible films after dipped in 2 or 4 % $CaCl_2$ could be shipped with good quality and less disorders at 5°C ±1 and 85% ±5 % RH followed by 2 weeks as a marketing periods at 20± 2°C. These treatments are safety environmental treatments especially with exporting pomegranate fruits to external markets.

REFERENCES

1. Kader, A.A., A. Chardas and S. Elyatem, 1984. Responses of pomegranate to ethylene treatment and storage temperature. Calif. Agr., 38: 14-15.
2. Artes, F., J.A. Tudela and R. Villaescusa, 2000. Thermal postharvest treatments for improving pomegranate quality and shelf life. Postharvest Biol. Technol., 18: 245-251.
3. Salunke, D.K. and B.B. Desai, 1986. Low temperature storage of pomegranate fruits. In: Postharvest Biotechnology of Fruits, vol. 2. CRC Press, Boca Raton, FL, pp: 65-67.
4. Koksal, A.I., 1989. Research on the storage of pomegranate (cv. Gok Bahce) under different conditions. Acta Hort., 258: 295-302.
5. Gil, M.I., R. Sanchez., J.G. Marin and F. Artes, 1996. Quality changes in pomegranates during ripening and cold storage. Z. Lebensm. Unters. Forsch., 202: 481-485.
6. Holland, D. and I. Bar Ya'akov, 2008. The pomegranate: New interest in an ancient fruit. Chronica Hort., 48: 12-15.
7. Kirkby, E.A. and D.J. Pilbeaam, 1984. Calcium as a plant nutrient. Plant cell Environ., 7: 397-405.
8. Arhtar, A., N.A. Abbasi and A. Hussain, 2010. Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. Pak. J. Bot., 42: 181-188.
9. Demarty, M., C. Morvan and M. Thellier, 1984. Ca and the cell wall. Plant Cell Environ., 7: 441-448.
10. Lara, I., P. García and M. Vendrell, 2004. Modifications in cell wall composition after cold storage of calcium-treated strawberry (Fragaria × ananassa Duch.) fruit. Postharvest Biology and Technol., 34: 331-339.
11. Kazemi, M., M. Aran and S. Zamani, 2011. Effect of Calcium Chloride and Salicylic Acid Treatments on Quality Characteristics of Kiwifruit (Actinidia deliciosa cv. Hayward) During Storage. American J. Plant Physiol., 6: 183-189.
12. Ferguson, I.B., 1984. Calcium in plant senescence and fruit ripening. Plant Cell Environ., 7: 477- 489.
13. White, P.J. and M.R. Broadley, 2003. Calcium in plants. Ann. Bot., 92: 487-511.
14. Mahajan, B.V.C. and A.S. Dhatt, 2004. Studies on postharvest calcium chloride application on storage behaviour and quality of Asian pear during cold storage. Intl. J. Food Agri. And Environment, 2: 157-159.

15. Dimitrios, G. and D.D. Pavlina, 2005. Summer-pruning and preharvest calcium chloride sprays affect storability and low temperature breakdown incidence in kiwifruit. Postharvest Biology and Technol., 36: 303-308.
16. Ramezanian, A. and M. Rahemi, 2007. Effect of Pre-storage application of spermidine, calcium chloride and hot water on chilling injury of cold storage pomegranate Acta Horticulturae, 877: 4-50.
17. Ben-Yehoshua, S., 1985. Individual seal packaging of fruits and vegetables in plastic film — a new postharvest technique. Hort Science, 20: 32-37.
18. Risse, L.A., 1989. Individual film wrapping of Florida fresh fruit and vegetables. Acta Hort., 258: 263-270.
19. Santerre, C.R., T.F. Leach and J.N. Cash, 1989. The influence of the sucrose polyester, Semperfresh™, on the storage of Michigan grown 'McIntosh' and 'Golden delicious' apples.
20. Chai, Y., D.B. Ott and J.N. Cash, 1991. Shelf-life extension of Michigan apples using sucrose polyester. J. Food Processing Preservation, 15: 197-214.
21. Park, H.J., J.M. Bunn, P.J. Vergano and R.F. Testin, 1994. Gas permeation and thickness of the sucrose polyesters, semperfresh ™ coatings on apples. J. Food Processing Preservation, 18: 349-358.
22. Banks, N.H., 1984. Some effects of TAL Pro-long coating on ripening bananas. J. Exp. Bot. 35: 127-137. Banks, N.H., Cleland, D.J., Cameron, A.C., Beaudry, R.M.,
23. Motlagh, F.H. and P.C. Quantick, 1988. Effect of permeable coatings on the storage life of fruits. I. Pro-long treatment of limes (Citrus aurantifolia cv. Persian). Int. J. Food Sci.Technol., 23: 99-105.
24. Dhalla, R. and S.W. Hanson, 1988. Effect of permeable coatings on the storage life of fruits. II. Pro-long treatment of mangoes (*Mangifera indica* L. cv. Julie). Int. J. Food Sci. Technol., 23: 107-112.
25. Nisperos-Carriedo, M.O., P.E. Shaw and E.A. Baldwin, 1990. Changes in volatile flavour components of pineapple orange juice as influenced by the application of lipid and composite films. J. Agric. Food Chem., 38: 1382-1387.
26. Nanda, S., D.V.S. Rau and S. Krishnamurthy, 2001. Effects of shrink film wrapping and storage temperature on the shelf life and quality of pomegranate fruits cv. Ganesh. Postharvest. Biol. Technol., 22: 61-69.
27. Navjot, G., S.K. Jawandha and P.S.Gill, 2011. Effect of calcium on cold storage and post-storage quality of peach J Food Sci Technol., 48: 225-229.
28. Palou, L., H. Carlos, G. Aguilar and G. David, 2007. Combination of postharvest antifungal chemical treatments and controlled atmosphere storage to control gray mold and improve storability of 'Wonderful' pomegranates. Postharvest Biology and Technol., 43: 133-142.
29. Karp, D., 2006. The pomegranate: For one and all. Fruit Gardener, 38: 8-12.
30. A.O.A.C. 1990. Official Methods of analysis 15th Edition. Association of Official Anal Chem. Vol. (2) pp: 918 (942015), Washington, D.C., USA.
31. A.O.A.C. 1970. Association of Official Analytical Chemists Methods of Analysis 10th Ed. Washington D.C., USA, pp: 100-215.
32. Geza H., G.F. Parsons and L.R. Mattick, 1984. Physiological and Biochemical Events During Development and Maturation of Grape Berries. American Society for Enology and Viticulture, 35: 220-227.
33. Snedecor, C.W. and W.G. Cochran, 1982. Statistical Methods. 7th Ed. The Iowa State Univ. Press. Ames. Iowa, USA.
34. Hale, P.W., W.R. Miller and J.J. Smool, 1986. Evaluation of a heat shrinkable copolymer film coated with imazalil for decay control of Florida grapefruits. Trop. Sci., 26: 67-71.
35. Ladaniya, M.S., R.K. Sonkar and H.C. Dass, 1997. Evaluation of heat shrinkable film wrapping of 'Nagpur' Mandarin (*Citrus reticulata*, Blanco) for storage. J. Food Sci. Technol., 34: 324-337.
36. Lester, G.E. and M.A. Grusak., 1999. Postharvest application of calcium and magnesium to honeydew and netted muskmelons: Effects on tissue ion concentrations, quality and senescence. J. Amer. Soc. Hort. Sci., 124: 545-552.
37. Ben-Yehoshua, S., B. Shapiro, Z.E. Chen and S. Lurie, 1983. Mode of action of plastic film I extending life of lemon and bell pepper fruits by alleviation of water stress. Plant Physiol., 73: 87-93.
38. Shuiliang, C., Y. Zhende, L. Laiye, L. MeiXue, S.L.Chen, Z.D. Yang, J.Y. Lai and M.X. Liu, 2002. Studies on freshness keeping technologies of loquat. South China Fruits, 31: 28-30.
39. Stanley, J.K., 1991. Post-Harvest Physiology of Perishable Plant Products. Van Nestrand Reinhold, New York.
40. Veltman, R.H., R.M. Kho, A.C.R. Van Schaik, M.G. Sanders and J. Oosterhaven, 2000. Ascorbic acid and tissue browning in pears (*Pyrus communis* L. cvs Rocha and Conference) under controlled atmosphere conditions. Postharvest Biology and Technol., 19: 129-137.

41. Ruoyi, K., Y. Zhifang and L.Z. Zhaoxin, 2005. Effect of coating and intermittent warming on enzymes, soluble pectin substances and ascorbic acid of Prunus persica (cv. Zhonghuashoutao) during refrigerated storage. Food Research International, 38: 331-336.
42. Anonymous, 1998. Postharvest Technology of 'Nagpur' Mandarins. National Research Centre for Citrus (ICAR), Nagpur, India, pp: 121-125.
43. Yang, S.F. and N.E. Hoffman, 1994. Ethylene biosynthesis and its regulation in higher plants.Ann. Rev.Plants Physiol., 35: 155-159.
44. Wang, C.Y., 1994 Chilling injury of tropical horticultural commodities. Hort. Science, 29: 986- 988.