

**RETARDING THE DETERIORATION OF WINTER MATURING GUAVA (*Psidium guajava* L.) FRUITS DURING STORAGE BY POSTHARVEST TREATMENTS OF CALCIUM CHLORIDE AND HYDROGEN PEROXIDE**

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By

**M. A. A. Mohamed and A. F. Abd El-khalek\***

*Fruit Handling Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.*

*\* Horticulture Department, Faculty of Agriculture, Tanta University, Tanta, Egypt.*

**ABSTRACT**

Guavas are perishable fruits and have relatively short marketing life after harvest. The present experiment was conducted in 2015 and 2016 seasons to evaluate the effect of calcium chloride ( $\text{CaCl}_2$ ), hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) and their combinations as postharvest treatments on quality attributes of 'Etmany' winter maturing guavas during cold storage. All treated fruits were stored at  $8\pm 1^\circ\text{C}$  and  $90\pm 5\%$  relative humidity (RH) for 21 days followed by two days of shelf life at ambient conditions ( $18\text{-}23^\circ\text{C}$  and  $55\text{-}65\%$  RH) as a simulation for marketing period. The changes of physical and chemical attributes of the fruits were determined at weekly intervals followed by two days shelf life. All applied treatments reduced the deterioration of physical and chemical attributes in comparison to the untreated fruits (control). The combined treatments of 2 or 4%  $\text{CaCl}_2$  with  $\text{H}_2\text{O}_2$  at 1 or 2% were superior in retarding the deterioration of fruit quality during storage as compared to the individual treatments and the control. These applications significantly reduced physiological weight loss, reduced decay incidence, maximized marketable percentage and maintained visual appearance score as well as decreased the loss of firmness, hue angle and lightness values. Also, these applications significantly slowed the increase of fruit contents of total soluble solids and total soluble solids/titratable acidity ratio, as well as significantly reduced the rate of losses in vitamin C and titratable acidity during storage period. Moreover, pre-storage applications of 4%  $\text{CaCl}_2$  plus  $\text{H}_2\text{O}_2$  at 1 or 2% were the most effective in this respect in comparison to the other treatments. Thus, pre-storage treatments of 4%  $\text{CaCl}_2$  plus  $\text{H}_2\text{O}_2$  at 1 or 2% are effective and promising methods for delaying ripening and senescence respect processes as well as retarding the deterioration of postharvest quality of 'Etmany' winter maturing guavas during cold storage at  $8^\circ\text{C}$  for up to 21 days followed by two days shelf life at  $18\text{-}23^\circ\text{C}$ .

**Key words:** *winter maturing guavas, calcium chloride, hydrogen peroxide, pre-storage, decay, fruit quality.*

**1. INTRODUCTION**

Guava (*Psidium guajava* L.) is one of the most well known edible fruits grown widely throughout tropical and subtropical regions worldwide. Guava fruits are good source of vitamins A, B, C and minerals (Pérez-Gutiérrez *et al.*, 2008). They are very popular to the Egyptian consumers due to its affordable price and high nutritional value. In Egypt, the total guava area reached 36.529 feddans, out of which 33.706 feddans are fruiting. They yield about 343.702 tons (Anonymous, 2016). Guava fruit is highly perishable, and bruising easily after harvest because of the delicate outer skin that offers very little protection against injury. Guava

is a climacteric fruit, which ripens rapidly after harvest because of the increase in ethylene production and the high respiration rate (Reyes & Paul, 1995). The climacteric peak of guava fruits is reached after four to five days from harvest followed by the senescence process, which leads to a loss in fruit commercial value (Bashir & Abu-Goukh, 2003). All of the above mentioned problems necessitate the development of suitable protocol to extend the storage life of guava fruits and maintain the postharvest quality. Various techniques of low cost and high efficiency can be used in this respect; calcium chloride, and hydrogen peroxide pre-storage applications, and fruit storage at low temperature

have been used in order to slow down ripening and senescence processes, reducing spoilage and maintaining fruit quality (Ismail *et al.*, 2010; Reena, 2016 and Mohamed *et al.*, 2016).

Calcium is an important constituent of plant tissues and has a vital role in maintaining and modulating various cell functions by increasing membrane stability, cell strength and maintaining the cell to cell contact, thus improving the turgidity of cell wall and retarding tissue softening of fruits and vegetables (Demarty *et al.*, 1984 and Diana *et al.*, 2007). In addition, calcium treatment can delay the onset of the ethylene climacteric period and climacteric peak (Shirzadeh *et al.*, 2011 and Reena, 2016).

Calcium treatment enhances tissue developed resistance to fungal infection by stabilizing or strengthening cell walls by making them more resistant to harmful enzymes produced by fungi (Conway *et al.*, 1994 and Botelho *et al.*, 2000). Calcium chloride treatment extends the storage life by maintaining membrane integrity, reducing respiration rate, controlling disease incidence, delaying membrane lipid catabolism and quality retention of guava fruits (Hiwale & Singh, 2003 and Kumar *et al.*, 2012). In this concern, postharvest application of calcium chloride represents a safe and effective method for reducing ripening and senescence processes, controlling postharvest decay and softening, delaying color change and maintaining internal quality during storage and shelf life of guava fruits (Shaaban, 2006; Ismail *et al.*, 2010; Mahajan *et al.*, 2011; Reena 2016 and Phani *et al.*, 2016).

Hydrogen peroxide ( $H_2O_2$ ) is an environmental friendly compound and is known as an antiseptic because of its cytotoxic effects on many bacterial strains (Juven & Pierson, 1996). Postharvest treatment of  $H_2O_2$  has been proposed for disinfecting fruits and vegetables to reduce microbial populations (Sapers & Simmons, 1998).  $H_2O_2$  at low concentrations acts as a messenger molecule involved in adaptive signaling and triggering tolerance against various abiotic stresses (Dat *et al.*, 2000). It is considered a Generally Regarded As Safe (GRAS) as alternative and have regulatory effects on growth, development and quality of fruit (Ismail *et al.*, 2015). Meanwhile,  $H_2O_2$  was successfully used to control pathogens and increase the antioxidant enzyme activities without causing loss of physical and chemical quality during storage in wax apple fruits

(Khandaker *et al.*, 2012), oranges (Mohamed *et al.*, 2016). In this concern, immersing 'Maamoura' guavas in  $H_2O_2$  for four minutes before cold storage significantly reduced decay incidence, maintained firmness and improved visual appearance as well as preserved the internal chemical quality during cold storage at 8°C for 15 days (Ismail *et al.*, 2010). Moreover, immersing 'Valencia' oranges in 2%  $H_2O_2$  can control postharvest decay incidence, reduce weight loss percentage, increase marketable percentage, maintain firmness and preserve the internal quality during storage at 8°C for fifteen weeks (Mohamed *et al.*, 2016).

Winter crops of guavas are free from fruit fly infestation and fetch higher price as compared with the main season crops (Boora *et al.*, 2016). The reduction of losses and extension of postharvest life of guava fruits will help increase the market price. Therefore, the present study was conducted on winter 'Etmany' guavas to evaluate the impact of pre-storage application of calcium chloride and hydrogen peroxide separately, or in combinations, on postharvest decay and quality attributes during cold storage at  $8\pm 1^\circ C$  and  $90\pm 5\%$  relative humidity (RH), followed by two days shelf life ambient condition ( $18-23^\circ C$  and 55-65% RH).

## 2. MATERIALS AND METHODS

### 2.1. Plant materials and treatments

The present study was conducted during the two successive seasons (2015 and 2016) on 'Etmany' winter guava fruits. 'Etmany' guava trees are the vegetative clone of seedy guava that were propagated by root cuttings. The trees are grown in a private orchard in El-Qalubia Governorate, Egypt (latitude,  $30^\circ 17' N$ ; longitude,  $31^\circ 20' E$ ). Trees were about 10 years of age, planted at a spacing of 5 x 5 meters apart in a loamy clay soil under flooding irrigation system and subjected to standard agriculture practices as recommended by the Ministry of Agriculture and Land Reclamation, Egypt. Guava fruits were picked at the maturity stage (yellowish green) on the second week of February according to Silva *et al.* (1998) from almost similar trees. Fruits were apparently uniform in size and free of visible symptoms of infection. In both experimental seasons, fruits were harvested in plastic boxes (15 kg capacity) and immediately transferred to postharvest laboratory at the Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Once arrived to the laboratory, the fruits were

thoroughly washed, sorted and defective fruits, including wounded and other disorders, were excluded, where the rest were considered as sound fruits. The sound fruits at the same maturity stage were washed by 0.01% sodium hypochlorite water solution for two minutes to clean the surface of the fruits and then air dried at room temperature until visible moisture on the fruits surfaces disappeared completely. A total of 1296 clean sound fruits were selected and randomly divided into nine treatments with three replications and each replicate comprised 12 individual fruits (9 treatments x 4 storage periods x 3 replicates x 12 fruits). Fruits were dipped into one of the following treatments: (1) distilled water for untreated fruits (control), (2) calcium chloride (CaCl<sub>2</sub>) at 2%, (3) CaCl<sub>2</sub> at 4%, (4) hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) at 1%, (5) H<sub>2</sub>O<sub>2</sub> at 2%, (6) CaCl<sub>2</sub> at 2% + H<sub>2</sub>O<sub>2</sub> at 1%, (7) CaCl<sub>2</sub> at 2% + H<sub>2</sub>O<sub>2</sub> at 2%, (8) CaCl<sub>2</sub> at 4% + H<sub>2</sub>O<sub>2</sub> at 1% and (9) CaCl<sub>2</sub> at 4% + H<sub>2</sub>O<sub>2</sub> at 2%. Postharvest treatments were performed by dipping guava fruits for five minutes in five liter of aqueous solutions containing Tween-80 0.05% (v/v) to improve wettability and adherence to guavas surface, after that fruits were allowed to dry for 30 min at room temperature by electric fan. After that, the fruits of each treatment were placed into unsealed plastic bags with a thickness of 0.04 mm. and then the bags were packaged in cardboard boxes with dimensions of 45×35×10 cm. All experimental boxes were stored at 8±1°C and 90±5% RH for 21 days. All treatments were examined at harvest time and every seven days intervals of cold storage at 8±1°C plus two days shelf life at ambient conditions (18-23°C and 55-65% RH) as a shelf life period to examine the effect of pre-storage applications on the physical and the chemical characteristics of guava fruits.

## **2.2. Measurement of fruit weight loss, decay, marketable percentage and visual appearance**

Weight loss percentage was calculated by the following formula:  $[(A-B)/A \times 100]$ , where A is the initial fruit weight and B is the fruit weight after each period of cold storage.

Decay percentage was scored by the number of decayed fruits due to fungus or any microorganisms infection and calculated as a percentage of the initial number of stored fruits using the following formula:  $[(C/A) \times 100]$ , where A is the number of stored fruits and C is the number of decayed fruits after each period of cold storage.

Marketable percentage was calculated by the following equation:  $[(D/A) \times 100]$ , where A is the fruit weight before storage and D is the sound fruit weight after specified storage period.

Visual appearance was measured by a rating system and fruit was scored as very good = 9, good = 7, acceptable = 5, unacceptable = 3 and poor = 1

## **2.3. Measurement of fruit color and firmness**

Skin color was measured by using a Minolta CR-400 Chroma Meter (Minolta Co .ltd. Osaka, Japan). The color measurement was expressed in chromaticity values of lightness (L) and hue angle (h°). Three readings were taken at different locations of each guava fruit during each data observation date according to McGuire (1992).

Fruit firmness was measured in three guava fruits per replication at two equatorial sites by using penetrometer (FT-327, Effegi hand-held, facchini, Alfonsine, Italy) equipped with an 8 mm cylindrical stainless steel plunger tip (Watkins & Harman, 1981). Two readings were taken on the flesh of each fruit after peeling. The firmness value was expressed in terms of Newton/cm<sup>2</sup>.

## **2.4. Measurement of contents in vitamin C, total soluble solids (TSS), titratable acidity (TA) and TSS/TA ratio in pulp**

The juice was extracted by crushing the pulp of guavas and straining through a muslin cloth. The extracted juice was used for measuring internal fruit quality as follow:

Vitamin C content was estimated according to A.O.A.C. (2000). Samples of fruit juice were used, oxalic acid solution was added to each sample and titrated with 2,6-dichlorophenol-indophenol dye solution, and expressed as a milligram of ascorbic acid, and was calculated as mg/100 ml of the juice.

TSS content was measured using a hand refractometer, 0-32 scale (ATAGO N-1E, Japan) and expressed in °Brix after making the temperature correction at 20°C according to A.O.A.C. (2000).

TA was assayed based on the method of adopting the procedure described by A.O.A.C. (2000). Aliquots of fruit juice were titrated against 0.1 N NaOH in the presence of phenolphthalein as an indicator to the end point, and was calculated as grams of citric acid per 100 ml of juice.

TSS/TA ratio was calculated from the values recorded for fruit juice TSS and TA percentages determined.

## **2.5. Experimental design and statistical data analysis**

This experiment was arranged in a completely randomized design having three replicates and consisting of two factors; pre-storage treatments and storage periods. Data calculated as percentage were transformed to arcsine of square root before statistical analysis and non-transformed means are shown. The effects of treatments and cold storage period on different attributes were analyzed statistically by analysis of variance (ANOVA) using the MSTAT-C statistical package (M-STAT, 1993). Comparisons between means were done by Duncan's multiple range test (DMRT) at probability  $\leq 0.05$ .

## **3. RESULTS AND DISCUSSION**

### **3.1. Physical quality attributes of 'Etmany' guava fruits during storage as affected by pre-storage applications of calcium chloride (CaCl<sub>2</sub>), hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and their combinations**

#### **3.1.1. Fruit weight loss, decay incidence, marketable percentage and visual appearance**

Data in Tables (1,2,3 and 4) demonstrate that, weight loss and decay percentage of 'Etmany' guava fruits gradually and significantly increased with prolonging the cold storage period at 8°C plus two days shelf life at ambient temperature (18-23°C) in both seasons. In addition, guava fruits showed gradual and significant reduction in marketable percentage and visual appearance with the advancement of storage period during the two seasons. The results indicated that, the maximum weight loss (12.48 & 11.61 %) and decay percentage (16.78 & 13.37 %) of 'Etmany' guavas were observed at the end of storage period in the first and second seasons, respectively. Also, this period recorded the minimum marketable fruits percentage (73.26 & 76.92 %) and visual appearance score (5.81 & 4.81) in 2015 and 2016 seasons, respectively.

Also the data in Tables (1, 2, 3 and 4) reveal that, all pre-storage treatments showed significant lower fruit weight loss and decay percentages than untreated fruits (control). On the other hand, treated fruits showed significant higher percentage of marketable fruits and visual appearance score as compared to the control in both seasons. In addition, dipping guava fruits in 2 or 4% CaCl<sub>2</sub> in combination with H<sub>2</sub>O<sub>2</sub> at 1 or

2% for five minutes were more effective in reducing weight loss and decay percentages. Moreover, these treatments increased the percentage of marketable fruits and visual appearance score than individual treatments during cold storage period at 8°C plus two days shelf life at ambient temperature (18-23°C).

The data also indicated that, pre-storage applications of 4% CaCl<sub>2</sub> in combination with H<sub>2</sub>O<sub>2</sub> at 2% followed by 4% CaCl<sub>2</sub> in combination with H<sub>2</sub>O<sub>2</sub> at 2% had the most effectiveness in reducing guava fruits deterioration of fruit weight, marketable percentage and visual appearance score as compared to the other treatments. Moreover, these treatments also had the least decay incidence during cold storage plus two days shelf life in the two seasons in comparison to the control.

Pre-storage treatment of 'Etmany' guava fruits with 4% CaCl<sub>2</sub> plus 2% H<sub>2</sub>O<sub>2</sub> recorded the least significant weight loss (4.76 & 3.81 %) and decay incidence (3.43 & 2.73 %) and recorded the highest marketable fruits (92.08 & 93.65 %) and visual appearance score (8.58 & 8.58) in 2015 and 2016 seasons, respectively. Whereas, untreated fruits (control) exhibited the highest weight loss (12.67 & 11.80 %) and decay incidence (16.74 & 13.34 %) and also recorded the lowest marketable fruits (73.43 & 77.02 %) and visual appearance score (5.33 & 4.92) in the first and second seasons, respectively.

The interaction effect between pre-storage applications and storage periods showed significant differences at  $p \leq 0.05$  for weight loss, decay, marketable percentage and visual appearance of 'Etmany' guava fruits in both seasons.

The reduction in fruit weight loss and decay percentages by pre-storage applications of CaCl<sub>2</sub> and H<sub>2</sub>O<sub>2</sub> especially 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub> might be due to their positive role in decreasing water evaporation from the surface of the fruits and enhancing resistant ability of fruits against pathogens as mentioned by Mohamed *et al.* (2016) and Reena (2016). Consequently, these treatments increased marketable fruit percentage and visual appearance score (Ismail *et al.*, 2010 and Mohamed *et al.*, 2016). In addition, the highest weight loss and decay percentages as well as the lowest marketable percentage and visual appearance score of untreated guavas fruits (control) were due to increased breakdown of fruits associated with

**Table (1): Weight loss percentages of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
	Season 2015				
Distilled water (control)	4.44 j-m	10.63 def	15.04 b	20.59 a	12.67 A
2% calcium chloride (CaCl <sub>2</sub> )	2.80 lm	6.02 h-k	9.95 d-g	14.17 bc	8.23 B
4% CaCl <sub>2</sub>	2.54 lm	6.04 h-k	9.63 d-g	12.13 cde	7.59 BC
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	2.83 lm	6.20 h-k	12.00 cde	14.68 bc	8.93 B
2% H <sub>2</sub> O <sub>2</sub>	2.67 lm	6.18 h-k	9.34 d-g	12.18 cd	7.59 BC
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	2.34 lm	4.25 j-m	7.99 f-i	10.91 def	6.37 CD
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	2.28 lm	4.21 j-m	7.10 g-j	10.24 def	5.96 DE
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	2.15 m	4.17 j-m	6.26 h-k	9.14 efg	5.43 DE
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	2.01 m	3.47 klm	5.28 i-l	8.28 fgh	4.76 E
Means	2.67 D	5.68 C	9.18 B	12.48 A	
	Season 2016				
Distilled water (control)	3.48 ijk	9.74 cd	14.19 b	19.80 a	11.80 A
2% calcium chloride (CaCl <sub>2</sub> )	1.83 kl	5.08 ghi	9.05 cde	13.31 b	7.32 BC
4% CaCl <sub>2</sub>	1.56 kl	5.10 ghi	8.73 de	11.26 c	6.66 C
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	1.86 kl	5.26 ghi	11.12 c	13.82 b	8.02 B
2% H <sub>2</sub> O <sub>2</sub>	1.70 kl	5.24 ghi	8.43 de	11.30 c	6.67 C
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	1.37 kl	3.29 i-l	7.07 efg	10.02 cd	5.44 D
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	1.30 kl	3.25 i-l	6.17 fgh	9.35 cde	5.02 D
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	1.17 kl	3.22 i-l	5.33 ghi	8.24 def	4.49 DE
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	1.03 l	2.51 jkl	4.33 hij	7.36 efg	3.81 E
Means	1.70 D	4.74 C	8.27 B	11.61 A	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**Table (2): Decay percentages of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
	Season 2015				
Distilled water (control)	0.00 j	13.61 ef	21.43 b	31.93 a	16.74 A
2% calcium chloride (CaCl <sub>2</sub> )	0.00 j	6.99 hi	12.73 efg	19.46 bc	9.79 B
4% CaCl <sub>2</sub>	0.00 j	4.54 i	11.54 fg	15.76 de	7.96 C
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	0.00 j	6.24 i	13.20 ef	19.92 b	9.84 B
2% H <sub>2</sub> O <sub>2</sub>	0.00 j	5.46 i	11.91 fg	16.93 cd	8.58 BC
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.00 j	0.00 j	6.23 i	13.68 ef	4.98 D
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.00 j	0.00 j	5.97 i	12.82 efg	4.70 DE
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.00 j	0.00 j	5.72 i	10.90 fg	4.15 DE
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.00 j	0.00 j	4.09 i	9.63 gh	3.43 E
Means	0.00 D	4.09 C	10.31 B	16.78 A	
	Season 2016				
Distilled water (control)	0.00 i	10.84 ef	17.07 b	25.43 a	13.34 A
2% calcium chloride (CaCl <sub>2</sub> )	0.00 i	5.57 h	10.14 f	15.50 bc	7.80 B
4% CaCl <sub>2</sub>	0.00 i	3.62 h	9.19 fg	12.55 de	6.34 C
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	0.00 i	4.97 h	10.51 ef	15.87 b	7.84 B
2% H <sub>2</sub> O <sub>2</sub>	0.00 i	4.35 h	9.49 fg	13.49 cd	6.83 BC
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.00 i	0.00 i	4.96 h	10.90 ef	3.96 D
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.00 i	0.00 i	4.76 h	10.21 f	3.74 DE
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.00 i	0.00 i	4.56 h	8.68 fg	3.31 DE
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.00 i	0.00 i	3.26 h	7.67 g	2.73 E
Means	0.00 D	3.26 C	8.22 B	13.37 A	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**Table(3):**Marketable percentages of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C

Pre-storage applications	Storage period (days)				Means
	0	7	14	21	
	Season 2015				
Distilled water (control)	95.56 a	77.36 ghi	66.74 k	54.06 l	73.43 F
2% calcium chloride (CaCl <sub>2</sub> )	97.20 a	87.43 cd	78.59 fgh	69.74 k	83.24 E
4% CaCl <sub>2</sub>	97.46 a	89.67 bc	80.08 efg	74.90 ij	85.53 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	97.17 a	87.98 bcd	76.61 hi	68.39 k	82.53 E
2% H <sub>2</sub> O <sub>2</sub>	97.33 a	88.70 bcd	79.78 fgh	73.18 j	84.75 D
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	97.66 a	95.75 a	86.06 d	76.92 ghi	89.10 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	97.72 a	95.79 a	87.27 cd	78.25 fgh	89.76 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	97.85 a	95.83 a	88.42 bcd	80.93 ef	90.76 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	97.99 a	96.53 a	90.88 b	82.94 e	92.08 A
Means	97.33 A	90.56 B	81.60 C	73.26 D	
	Season 2016				
Distilled water (control)	96.52 a	80.61 hij	71.15 l	59.81 m	77.02 G
2% calcium chloride (CaCl <sub>2</sub> )	98.17 a	89.65 bcd	81.73 ghi	73.74 l	85.82 EF
4% CaCl <sub>2</sub>	98.44 a	91.45 bc	82.99 fgh	78.31 jk	87.80 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	98.14 a	90.05 bcd	79.71 ijk	72.55 l	85.11 F
2% H <sub>2</sub> O <sub>2</sub>	98.30 a	90.64 bcd	82.81 fgh	76.92 k	87.17 DE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	98.63 a	96.71 a	88.14 de	80.19 hij	90.92 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	98.70 a	96.75 a	89.30 cd	81.40 ghi	91.54 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	98.83 a	96.78 a	90.40 bcd	83.78 fg	92.45 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	98.97 a	97.49 a	92.58 b	85.57 ef	93.65 A
Means	98.30 A	92.24 B	84.31 C	76.92 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**Table (4):** Visual appearance of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C

Pre-storage applications	Storage period (days)				Means
	0	7	14	21	
	Season 2015				
Distilled water (control)	9.00 a	6.33 ef	4.33 h	1.67 i	5.33 D
2% calcium chloride (CaCl <sub>2</sub> )	9.00 a	8.67 a	6.67 def	5.00 gh	7.33 C
4% CaCl <sub>2</sub>	9.00 a	9.00 a	7.67 a-d	6.33 ef	8.00 AB
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	9.00 a	8.67 a	6.67 def	5.00 gh	7.33 C
2% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	7.33 b-e	5.67 fg	7.75 BC
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.00 abc	6.67 def	8.17 AB
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.00 abc	7.00 cde	8.25 AB
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.33 ab	7.33 b-e	8.42 A
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.67 a	7.67 a-d	8.58 A
Means	9.00 A	8.63 A	7.30 B	5.81 C	
	Season 2016				
Distilled water (control)	9.00 a	6.00 fgh	3.67 i	1.00 j	4.92 F
2% calcium chloride (CaCl <sub>2</sub> )	9.00 a	8.67 ab	6.33 efg	5.33 gh	7.33 DE
4% CaCl <sub>2</sub>	9.00 a	9.00 a	7.33 b-e	6.00 fgh	7.83 BCD
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	9.00 a	8.33 abc	6.33 efg	5.00 h	7.17 E
2% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	7.00 c-f	5.33 gh	7.58 CDE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	7.67 a-d	6.67 def	8.08 ABC
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.00 a-d	7.33 b-e	8.33 AB
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.00 a-d	7.67 a-d	8.42 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	9.00 a	9.00 a	8.33 abc	8.00 a-d	8.58 A
Means	9.00 A	8.56 B	6.96 C	5.81 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

higher respiratory rate and cellular metabolic activities (Hiwale & Singh, 2003 and Reena, 2016), thus the control treatment hastened ripening and senescence processes of guavas. Moreover,

increasing weight loss and decay incidence of guavas during storage are attributed to the increase in ripening and senescence processes of guava fruits (Hiwale & Singh, 2003 and Reena,

2016). Similar findings were obtained by Hiwale & Singh (2003), Shaaban (2006), Mahajan *et al.* (2011), Kumar *et al.* (2012), Phani *et al.* (2016), Dohre (2016) and Reena (2016). They reported that, weight loss percentage and decay incidence of guavas were reduced by dipping fruits in CaCl<sub>2</sub> treatment in comparison to the untreated fruits (control) during cold storage and shelf life. Furthermore, they illustrated that, fruits weight loss and decay incidence gradually and significantly increased with prolonging of storage period.

In addition, these results are in harmony with the findings of (Ismail *et al.*, 2010) who reported that, dipping ‘Maamoura’ guava fruits in 2% CaCl<sub>2</sub> or 2% H<sub>2</sub>O<sub>2</sub> for four minutes reduced weight loss and decay percentages as well as increased visual appearance score during cold storage at 8°C for 15 days in comparison to the untreated fruits. Moreover, weight loss percentage and decay incidence of ‘Valencia’ oranges were reduced by soaking fruits in 2% H<sub>2</sub>O<sub>2</sub> for five minutes and also this application increased marketable fruit percentage as compared to untreated fruits during cold storage at 8°C for fifteen weeks (Mohamed *et al.*, 2016). In addition, weight loss and decay percentages gradually increased with the advancement of cold storage period as well as marketable fruits and visual appearance decreased too.

### 3.1.2. Fruit firmness

Fruit firmness is often a major quality characteristic judged by the consumer and it is extremely important in overall product acceptance. Fruit firmness changes during 21 days of cold storage at 8°C plus two days shelf life at ambient temperature (18-23°C) are shown in Table (5). The data in the present study indicate that, a gradual and significant decrease in fruit firmness was observed with the progress of cold storage period at 8°C followed by two days shelf life at ambient temperature (18-23°C) in both seasons. The results indicated that, the minimum flesh firmness of ‘Etmany’ guavas was recorded at the end of storage period and the values reached of 15.92 & 14.82 N/cm<sup>2</sup> in the first and second seasons, respectively.

The data in Table (5) also showed that, the firmness values of soaking ‘Etmany’ guava fruits in CaCl<sub>2</sub> and H<sub>2</sub>O<sub>2</sub> were significantly higher as compared to the untreated fruits (control). In addition, immersing guavas in CaCl<sub>2</sub> at 2 or 4% plus H<sub>2</sub>O<sub>2</sub> at 1 or 2% was more effective in maintaining fruit firmness than individual treatments and the control in both seasons. The data in the current experiment indicated that, immersing ‘Etmany’ guavas in 4% CaCl<sub>2</sub> plus 2% H<sub>2</sub>O<sub>2</sub> recorded the highest value of flesh firmness (6.07 & 5.89 N/cm<sup>2</sup>) in 2015 and 2016 seasons. On the contrary, the

**Table (5): Firmness (N/cm<sup>2</sup>) of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
	Season 2015				
Distilled water (control)	6.76 a	4.09 h-k	3.00 lm	1.83 n	3.92 F
2% calcium chloride (CaCl <sub>2</sub> )	6.84 a	4.91 e-h	3.92 ijk	2.44 mn	4.53 DE
4% CaCl <sub>2</sub>	6.87 a	5.24 def	4.41 f-j	2.80 lm	4.83 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	6.83 a	4.72 e-i	3.57 jkl	2.21 mn	4.33 E
2% H <sub>2</sub> O <sub>2</sub>	6.86 a	5.18 def	4.30 g-k	2.76 lm	4.77 D
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	6.88 a	5.92 bcd	4.83 e-h	3.49 kl	5.28 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	6.90 a	6.09 abc	5.13 d-g	3.85 ijk	5.49 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	6.91 a	6.62 ab	5.50 cde	4.18 h-k	5.80 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	6.93 a	6.85 a	5.78 cd	4.71 e-i	6.07 A
Means	6.86 A	5.51 B	4.49 C	3.14 D	
	Season 2016				
Distilled water (control)	6.57 a	3.97 h-k	2.92 lmn	1.78 o	3.81 F
2% calcium chloride (CaCl <sub>2</sub> )	6.64 a	4.77 e-h	3.81 ijk	2.37 no	4.40 DE
4% CaCl <sub>2</sub>	6.68 a	5.09 def	4.28 f-j	2.72 lmn	4.69 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	6.63 a	4.58 e-i	3.47 kl	2.15 no	4.21 E
2% H <sub>2</sub> O <sub>2</sub>	6.67 a	5.03 def	4.18 g-k	2.68 mn	4.64 D
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	6.68 a	5.76 bcd	4.69 e-h	3.39 klm	5.13 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	6.70 a	5.92 abc	4.98 d-g	3.75 jk	5.34 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	6.71 a	6.43 ab	5.35 cde	4.06 h-k	5.64 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	6.73 a	6.65 a	5.61 cd	4.57 e-i	5.89 A
Means	6.67 A	5.36 B	4.37 C	3.05 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

untreated fruits (control) showed the least firmness value (3.92 & 3.81 N/cm<sup>2</sup>) in the first and second seasons, respectively.

Referring to the interaction effect, there was a significant interaction between pre-storage treatments and storage periods at  $p \leq 0.05$  for firmness in both seasons of this study.

Indeed, calcium ion forms stabilize cellular membranes by holding the cells altogether and delaying senescence in horticultural crops (Diana *et al.*, 2007). Therefore, the retention of firmness in 'Etmany' guavas treated with CaCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub> and their combinations, especially those treated with 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub>, could be attributed to the role of these compounds in maintaining cellular organization and obstructing cell wall enzyme activities as documented by Mohamed *et al.* (2016) and Reena (2016). Thus, these treatments increased wall strength and cell cohesion, thereby retarding tissue softening than the untreated fruits (control) that showed minimum flesh firmness.

In addition, the reduction in flesh firmness of 'Etmany' guavas with the progress of storage could be attributed to the increase in the activities of cell wall hydrolysis enzymes and the degradation in cellular structures (Jain *et al.*, 2003).

The observations in the current investigation are very close to those obtained by Hiwale & Singh (2003), Shaaban (2006), Mahajan *et al.* (2011), Kumar *et al.* (2012), Phani *et al.* (2016) and Reena (2016) They showed higher firmness by treating guava fruits with CaCl<sub>2</sub> as compared to untreated fruits during cold storage and shelf life. Moreover, the authors illustrated that, fruit firmness gradually and significantly decreased with prolonging of storage period. In addition, our results fall in line with the earlier reports of Mohamed *et al.* (2016) who reported that, dipping 'Valencia' oranges in H<sub>2</sub>O<sub>2</sub> at 2% for five minutes reduced the deterioration rate in fruit firmness during cold storage at 8°C for fifteen weeks in comparison to untreated fruits.

### **3.1.3. Fruit skin color and lightness**

Color is an important factor determining the appearance of fruits and consequently its quality. Skin color development represented as hue angle value (yellowish green, more than 90 and greenish yellow or yellow, less than 90) and brightness represented as lightness. The data in Tables (6 and 7) revealed that, skin color of 'Etmany' guava fruits changed directly from yellowish green to yellow with the progress of

cold storage at 8°C plus two days shelf life at ambient temperature (18-23°C) in both seasons. Moreover, lightness values gradually and significantly decreased with prolonging of cold storage period plus two days shelf life during the two seasons in this study. The results showed that, the minimum hue angle and lightness of guavas were recorded at the end of storage period and the values reached of 82.52 & 78.19 and 70.36 & 72.17, respectively in the first and second seasons, respectively.

Data in Tables (6 and 7) also demonstrated that, dipping 'Etmany' guava fruits in CaCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub> and their combinations significantly delayed skin color development during cold storage period at 8°C followed by two days shelf life at ambient temperature (18-23°C) as compared to untreated guava fruits (control). In addition, these treatments significantly reduced the decrease in brightness than the untreated fruits (control) in both seasons. Thus, all pre-storage applications especially combined applications of 'Etmany' guava fruits were still greener and more bright than the untreated fruits (control). Treated 'Etmany' guava fruits with 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub> were superior in constricting the changing rate of skin color and decreasing rate of brightness. Thus, these applications showed the highest values of hue angle and lightness as compared to the other treated and untreated fruits (control).

Treated 'Etmany' guavas by 4% CaCl<sub>2</sub> in combination with 2% H<sub>2</sub>O<sub>2</sub> showed maximum values of hue angle (100.05 & 94.79) and lightness (79.62 & 80.67). On the other hand, untreated fruits (control) recorded the minimum values of hue angle (89.07 & 84.24) and lightness (70.56 & 70.39) in the first and second seasons, respectively.

The interaction effect between pre-storage treatments and storage periods showed significant difference interactions at  $p \leq 0.05$  for hue angle and lightness of 'Etmany' guava fruits during the two seasons in this research.

The higher hue angle and lightness values of 'Etmany' guavas treated with CaCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub> and their combinations especially treated fruits with 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub> as compared to untreated fruits (control) might be due to the slower change of colour (Jain *et al.*, 2003). In addition, a decrease of hue angle value with the advancement of storage period is attributed to the disappearance of the green color in fruits and appearance of yellow color (Dhillon & Kaur, 2013).

**Table (6): Color represented as hue angle of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
<b>Season 2015</b>					
Distilled water (control)	107.41 b	89.14 g-j	79.15 o	70.91 p	86.65 F
2% calcium chloride (CaCl <sub>2</sub> )	109.25 ab	91.84 e-h	82.92 k-o	80.12 no	91.03 DE
4% CaCl <sub>2</sub>	110.54 ab	93.17 efg	86.44 ijk	81.68 l-o	92.96 CD
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	109.21 ab	90.13 ghi	81.43 l-o	78.95 o	89.93 E
2% H <sub>2</sub> O <sub>2</sub>	109.61 ab	92.06 efg	84.60 j-n	80.46 mno	91.68 DE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	111.09 ab	96.32 cde	87.25 h-k	84.93 j-m	94.90 BC
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	111.49 ab	97.62 cd	89.85 ghi	85.83 i-l	96.20 B
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	112.30 a	99.88 c	92.84 efg	88.64 g-j	98.41 A
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	113.66 a	100.40 c	94.98 def	91.14 fgh	100.05 A
Means	110.51 A	94.51 B	86.61 C	82.52 D	
<b>Season 2016</b>					
Distilled water (control)	101.77 b	84.46 g-j	75.00 o	67.19 p	82.10 F
2% calcium chloride (CaCl <sub>2</sub> )	103.52 ab	87.02 e-h	78.57 k-o	75.91 no	86.25 DE
4% CaCl <sub>2</sub>	104.74 ab	88.28 efg	81.90 ijk	77.40 l-o	88.08 CD
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	103.48 ab	85.40 ghi	77.16 l-o	74.80 o	85.21 E
2% H <sub>2</sub> O <sub>2</sub>	103.86 ab	87.23 efg	80.15 j-n	76.24 mno	86.87 DE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	105.26 ab	91.26 cde	82.67 h-k	80.47 j-m	89.91 BC
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	105.64 ab	92.50 cd	85.13 ghi	81.33 i-l	91.15 B
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	106.40 a	94.63 c	87.96 efg	83.99 g-j	93.25 A
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	107.69 a	95.13 c	90.00 def	86.35 fgh	94.79 A
Means	104.70 A	89.55 B	82.06 C	78.19 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**Table (7): Lightness of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
<b>Season 2015</b>					
Distilled water (control)	84.03 a-e	76.40 g-k	66.80 n	60.17 o	71.85 F
2% calcium chloride (CaCl <sub>2</sub> )	85.44 a-d	77.49 f-j	71.09 k-n	66.76 n	75.20 E
4% CaCl <sub>2</sub>	85.67 a-d	79.95 c-h	74.59 h-l	69.89 lmn	77.53 CDE
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	85.41 a-d	77.12 f-j	71.26 k-n	66.96 n	75.19 E
2% H <sub>2</sub> O <sub>2</sub>	85.56 a-d	78.88 e-i	73.34 i-m	68.54 mn	76.58 DE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	85.83 abc	80.26 b-h	76.52 g-k	72.56 j-m	78.79 BCD
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	85.90 ab	80.73 a-g	77.40 f-j	73.28 i-m	79.33 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	86.02 ab	82.76 a-f	79.81 d-h	76.62 g-k	81.30 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	86.30 a	84.21 a-e	81.65 a-g	78.50 e-i	82.67 A
Means	85.57 A	79.76 B	74.72 C	70.36 D	
<b>Season 2016</b>					
Distilled water (control)	86.19 a-e	78.36 g-k	68.51 n	61.72 o	73.70 F
2% calcium chloride (CaCl <sub>2</sub> )	87.63 a-d	79.48 f-j	72.92 k-n	68.47 n	77.13 E
4% CaCl <sub>2</sub>	87.87 a-d	82.00 c-h	76.50 h-l	71.69 lmn	79.52 CDE
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	87.60 a-d	79.10 f-j	73.09 k-n	68.68 n	77.12 E
2% H <sub>2</sub> O <sub>2</sub>	87.75 a-d	80.90 e-i	75.23 i-m	70.30 mn	78.55 DE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	88.04 abc	82.33 b-h	78.49 g-k	74.42 j-m	80.82 BCD
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	88.10 ab	82.80 a-g	79.39 f-j	75.16 i-m	81.36 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	88.23 ab	84.88 a-f	81.86 d-h	78.59 g-k	83.39 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	88.52 a	86.38 a-e	83.75 a-g	80.52 e-i	84.79 A
Means	87.77 A	81.80 B	76.64 C	72.17 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

Moreover, a decrease in lightness value with the prolonging of storage period is due to fruit senescence (Mohamed *et al.*, 2016).

The results in the present study are in agreement with findings of Shaaban (2006) who reported that, hue angle and lightness values increased by treating guavas with CaCl<sub>2</sub> as compared to untreated fruits during storage and these values decreased with the advancement of storage period. Moreover, the application of 1% CaCl<sub>2</sub> was efficient in delaying loss of skin color of guavas during shelf life for 12 days (Kumar *et al.*, 2012). Furthermore, these findings are in accordance with the findings of Dhillon & Kaur (2013) on mango fruits where, CaCl<sub>2</sub> treatment showed a beneficial effect in constricted the variability in color than the control treatment. In addition, postharvest application of 2% H<sub>2</sub>O<sub>2</sub> delayed skin color development of stored 'Valencia' oranges by the increase of hue angle value and also reduced the deterioration of lightness value as compared to the untreated fruits (Mohamed *et al.*, 2016).

### **3.2. Chemical quality attributes as affected by pre-storage applications of calcium chloride, hydrogen peroxide and their combinations of 'Etmany' guava fruits during storage**

#### **3.2.1. Fruit content of vitamin C**

The data in Table (8) illustrated that, a decline trend in vitamin C content was observed with the advancement of cold storage period at 8°C plus two days shelf life at ambient temperature (18-23°C) in both seasons. Our results revealed that, minimum vitamin C content of 'Etmany' guavas was observed at the end of storage period and the values reached of 76.30 & 77.96 mg/100 ml juice in the first and second seasons, respectively.

The data in Table (8) clearly revealed that, all pre-storage applications significantly reduced the deterioration rate in vitamin C content as compared to the untreated fruits (control) during the cold storage period at 8°C followed by two days shelf life at ambient temperature (18-23°C) in both seasons.

Moreover, individual treatments of CaCl<sub>2</sub> were more effective in maintaining vitamin C content as compared to individual treatments of H<sub>2</sub>O<sub>2</sub> in both seasons. In addition, 'Etmany' guava fruits treated with the combination treatments especially those treated with 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub> had significantly the highest vitamin C content in the two seasons. Moreover, the loss of vitamin C content was

more rapid in the untreated fruits (control) during the two seasons under this investigation.

The data also indicated that, dipping 'Etmany' winter guavas in 4% CaCl<sub>2</sub> plus 2% H<sub>2</sub>O<sub>2</sub> treatment had the highest vitamin C content (102.14 & 103.76 mg/100 ml juice) in 2015 and 2016 seasons, respectively. On the contrast, the untreated fruits (control) recorded the lowest vitamin C content (82.30 & 83.91 mg/100 ml juice) in the first and the second seasons, respectively.

The data also declared that, there was a significant interaction among pre-storage treatments and storage periods at  $p \leq 0.05$  for vitamin C content of 'Etmany' guava fruits in both seasons in the current investigation.

Higher vitamin C content in 'Etmany' guavas treated with CaCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub> and their combinations especially those treated with 4% CaCl<sub>2</sub> in combination with 1 or 2% H<sub>2</sub>O<sub>2</sub> as compared to the untreated fruits might be ascribed to the levitation in the activity of antioxidant enzymes as documented by Khandaker *et al.* (2012) and Reena (2016). Thus, these treatments retarded the oxidation of vitamin C by slowing down the rate of conversion of ascorbic acid into dehydro ascorbic acid (Davey *et al.*, 2000). In addition, the loss of guavas content in ascorbic acid during storage period might be due to a rapid conversion of L-ascorbic acid into dehydroascorbic acid in the presence of oxidizing enzymes like ascorbic acid oxidase and ascorbate peroxidase (Davey *et al.*, 2000). These results are in agreement with those obtained by Hiwale & Singh (2003), Shaaban (2006), Mahajan *et al.* (2011), Phani *et al.* (2016), Dohre (2016) and Reena (2016). They all claimed that, guava fruits treated with CaCl<sub>2</sub> had higher vitamin C content than the untreated fruits and also they demonstrated that vitamin C decreased with the elongation of storage period. In addition, the obtained results were similar to those mentioned by Ismail *et al.* (2010) who stated that, immersing 'Maamoura' guava fruits in 2% CaCl<sub>2</sub> or 2% H<sub>2</sub>O<sub>2</sub> for four minutes plus fumigation with lemon grass oil treatment reduced the rate of Vitamin C degradation during cold storage at 8°C for 15 days as compared to the control treatment. In addition, these results are in harmony with the findings of Mohamed *et al.* (2016) who reported that immersing 'Valencia' oranges in 2% H<sub>2</sub>O<sub>2</sub> for five minutes reduced the deterioration of vitamin C as compared to the untreated fruits during cold storage at 8°C for fifteen weeks.

**Table (8): Vitamin C content (mg/100 ml juice) of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
<b>Season 2015</b>					
Distilled water (control)	110.77 ab	84.85 i-l	71.90 mn	61.67 o	82.30 G
2% calcium chloride (CaCl <sub>2</sub> )	112.31 a	92.12 f-i	81.90 kl	72.78 m	89.78 DE
4% CaCl <sub>2</sub>	113.85 a	94.55 efg	85.24 i-l	75.00 m	92.16 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	111.79 ab	87.27 h-k	74.76 m	65.00 o	84.71 FG
2% H <sub>2</sub> O <sub>2</sub>	112.82 a	93.33 e-h	78.57 lm	66.11 no	87.71 EF
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	114.36 a	97.58 def	89.52 g-j	83.33 jkl	96.20 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	114.87 a	100.00 cde	91.90 f-i	85.00 i-l	97.94 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	115.38 a	103.03 cd	93.81 e-h	87.22 h-k	99.86 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	115.90 a	105.45 bc	96.67 d-g	90.56 f-j	102.14 A
Means	113.56 A	95.35 B	84.92 C	76.30 D	
<b>Season 2016</b>					
Distilled water (control)	112.31 ab	86.67 j-m	73.33 op	63.33 q	83.91 F
2% calcium chloride (CaCl <sub>2</sub> )	113.85 a	93.94 f-i	83.33 lm	74.44 no	91.39 D
4% CaCl <sub>2</sub>	115.38 a	96.36 e-h	86.67 j-m	76.67 no	93.77 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	113.33 ab	89.09 i-l	76.19 no	66.67 q	86.32 EF
2% H <sub>2</sub> O <sub>2</sub>	114.36 a	91.52 g-k	80.00 mn	67.78 pq	88.41 E
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	115.90 a	99.39 def	90.95 h-k	85.00 klm	97.81 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	116.41 a	101.82 cde	93.33 f-j	86.67 j-m	99.56 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	116.92 a	104.85 cd	95.24 e-i	88.89 i-l	101.47 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	117.44 a	107.27 bc	98.10 efg	92.22 g-j	103.76 A
Means	115.10 A	96.77 B	86.35 C	77.96 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**3.2.2. Fruit contents of total soluble solids (TSS), titratable acidity (TA) and TSS/TA ratio**

The data in Table (9) demonstrate that, the maximum ‘Etmany’ guavas content of TSS was recorded at 14 days of cold storage period plus two days shelf life at ambient temperature (12.09 & 12.17 °Brix) followed by a significant decrease at the end of the experiment (11.96 & 12.04 °Brix) in 2015 and 2016 seasons, respectively. On the other side, declining trend of guava fruits content in TA was observed with prolonging of storage period in both seasons and the minimum guavas content of TA was observed at the end of storage period (0.64 & 0.58 g citric acid/100 ml juice) in the first and second seasons, respectively (Table 10). While, rising trend of TSS/TA ratio was recorded with the advancement of storage period in the two seasons and the maximum TSS/TA ratio of guava fruits was recorded at the end of the storage period (19.62 & 22.27) in 2015 and 2016 seasons, respectively (Table 11).

Statistical data in Table (9) showed that, immersing ‘Etmany’ guavas in 2 or 4% CaCl<sub>2</sub> in combination with 1 or 2% H<sub>2</sub>O<sub>2</sub> treatments slowed the increase of TSS content than the individual and the control treatments during cold storage period at 8°C followed by two days shelf life at ambient temperature (18-23°C) in both

seasons. In the control treatment, fruit content of TSS was increased till seven days of the storage period, while the peak of TSS was recorded a week later by individual treatments. After that, a decrease trend in the control and the individual treatments was noticed till the end of the storage period in the two seasons under this investigation. On the contrary, continuous increase of fruit content in TSS was noticed in combined treatments until end of the experiment.

Moreover, the data in Tables (10 and 11) revealed that, all pre-storage treatments of CaCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub> and their combinations of ‘Etmany’ guava fruits significantly maintained fruit content in TA as compared to the control in both seasons. In addition, these applications slowed the increase of TSS/TA ratio than the untreated fruits (control). Our results indicated that, treated ‘Etmany’ guava fruits with combined treatments especially those treated with 4% CaCl<sub>2</sub> in combination with H<sub>2</sub>O<sub>2</sub> at 1 or 2% had significantly the lowest fruit contents of TSS and TSS/TA ratio, on contrary had significantly the highest fruit content of TA in the two seasons.

The data in Tables (9, 10 and 11) also emerged that, soaking ‘Etmany’ guavas in 4% CaCl<sub>2</sub> plus 2% H<sub>2</sub>O<sub>2</sub> treatment had the lowest values of TSS (10.03 & 10.12 °Brix) and TSS/TA ratio (11.02 & 11.96) in 2015 and 2016

**Table (9): Total soluble solids contents (°Brix) of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
	Season 2015				
Distilled water (control)	8.53 no	12.40 ab	11.93 c-g	11.47 h-k	11.08 A
2% calcium chloride (CaCl <sub>2</sub> )	8.40 n-q	11.40 ijk	12.40 ab	11.80 e-i	11.00 A
4% CaCl <sub>2</sub>	8.27 opq	11.07 k	12.27 a-d	12.00 b-f	10.90 A
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	8.47 nop	11.53 g-j	12.47 a	11.67 f-i	11.03 A
2% H <sub>2</sub> O <sub>2</sub>	8.33 n-q	11.20 jk	12.33 abc	11.87 d-h	10.93 A
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	8.20 opq	9.20 l	12.13 a-e	12.47 a	10.50 B
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	8.13 opq	9.13 lm	11.93 c-g	12.27 a-d	10.37 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	8.07 pq	9.00 lm	11.80 e-i	12.20 a-e	10.27 C
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	8.00 q	8.73 mn	11.53 g-j	11.87 d-h	10.03 D
Means	8.27 D	10.41 C	12.09 A	11.96 B	
Season 2016					
Distilled water (control)	8.67 no	12.60 a	12.27 a-d	11.53 g-k	11.27 A
2% calcium chloride (CaCl <sub>2</sub> )	8.53 opq	11.47 h-k	12.53 ab	12.00 def	11.13 AB
4% CaCl <sub>2</sub>	8.40 opq	11.13 k	12.47 abc	12.20 a-d	11.05 B
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	8.60 op	11.60 f-j	12.60 a	11.87 d-h	11.17 AB
2% H <sub>2</sub> O <sub>2</sub>	8.47 opq	11.27 jk	12.47 abc	12.07 cde	11.07 AB
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	8.33 opq	9.47 l	12.13 b-e	12.47 abc	10.60 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	8.27 opq	9.40 l	11.93 d-g	12.20 a-d	10.45 CD
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	8.20 pq	9.27 lm	11.73 e-i	12.07 cde	10.32 D
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	8.13 q	9.00 mn	11.40 ijk	11.93 d-g	10.12 E
Means	8.40 D	10.58 C	12.17 A	12.04 B	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**Table (10): Titratable acidity (g citric acid/100 ml juice) of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C.**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
	Season 2015				
Distilled water (control)	0.82 g-k	0.65 o-r	0.57 rst	0.47 u	0.63 G
2% calcium chloride (CaCl <sub>2</sub> )	0.87 c-j	0.76 j-n	0.66 n-r	0.53 stu	0.70 EF
4% CaCl <sub>2</sub>	0.91 b-h	0.80 h-k	0.70 l-p	0.62 p-s	0.76 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	0.84 e-j	0.69 l-q	0.62 p-s	0.51 tu	0.66 FG
2% H <sub>2</sub> O <sub>2</sub>	0.89 b-i	0.78 i-m	0.68 m-q	0.59 q-t	0.74 DE
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.93 a-f	0.85 d-j	0.76 j-m	0.70 l-p	0.81 C
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.95 a-d	0.89 b-h	0.83 f-j	0.72 k-o	0.85 BC
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.98 ab	0.94 a-e	0.87 c-i	0.79 i-l	0.89 AB
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	1.02 a	0.96 abc	0.91 b-g	0.83 f-j	0.93 A
Means	0.91 A	0.81 B	0.73 C	0.64 D	
Season 2016					
Distilled water (control)	0.75 h-m	0.58 r-u	0.51 uvw	0.40 x	0.56 H
2% calcium chloride (CaCl <sub>2</sub> )	0.80 e-k	0.69 m-q	0.59 rst	0.47 vwx	0.64 F
4% CaCl <sub>2</sub>	0.84 b-g	0.74 i-n	0.64 o-r	0.55 stu	0.69 E
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	0.78 g-m	0.63 p-s	0.55 stu	0.45 wx	0.60 G
2% H <sub>2</sub> O <sub>2</sub>	0.82 c-i	0.71 k-o	0.62 qrs	0.53 tuv	0.67 EF
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.87 b-f	0.78 f-l	0.70 l-p	0.64 o-r	0.75 D
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.89 a-d	0.83 b-h	0.76 g-m	0.66 n-r	0.78 C
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	0.91 ab	0.87 b-e	0.81 d-j	0.72 j-n	0.83 B
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	0.95 a	0.89 abc	0.85 b-g	0.76 g-m	0.86 A
Means	0.85 A	0.75 B	0.67 C	0.58 D	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

**Table (11): Total soluble solids/titratable acidity ratio of ‘Etmany’ guava fruits as influenced by calcium chloride and hydrogen peroxide applications during storage time at 8±1°C plus two days shelf life at 18-23°C.**

Pre-storage applications	Storage period (days)				
	0	7	14	21	Means
<b>Season 2015</b>					
Distilled water (control)	10.41 opq	19.48 d-g	21.00 bcd	26.14 a	19.26 A
2% calcium chloride (CaCl <sub>2</sub> )	9.76 pq	15.03 k-n	18.90 d-h	22.69 bc	16.59 BC
4% CaCl <sub>2</sub>	9.10 pq	13.83 mn	17.52 f-k	19.56 d-g	15.00 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	10.06 pq	16.81 h-l	20.31 cde	23.19 b	17.59 B
2% H <sub>2</sub> O <sub>2</sub>	9.41 pq	14.42 lmn	18.42 d-i	20.04 def	15.57 CD
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	8.80 pq	10.86 op	15.89 i-m	17.91 e-j	13.36 E
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	8.54 pq	10.23 opq	14.49 lmn	17.03 g-l	12.57 EF
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	8.27 pq	9.67 pq	13.58 mn	15.62 j-m	11.79 FG
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	7.89 q	9.15 pq	12.65 no	14.39 lmn	11.02 G
Means	9.14 D	13.28 C	16.97 B	19.62 A	
<b>Season 2016</b>					
Distilled water (control)	11.51 mno	22.18 cde	24.41 bc	31.05 a	22.29 A
2% calcium chloride (CaCl <sub>2</sub> )	10.74 mno	16.59 hij	21.15 def	26.49 b	18.74 BC
4% CaCl <sub>2</sub>	9.98 no	15.20 jk	19.59 e-h	22.18 cde	16.74 D
1% hydrogen peroxide (H <sub>2</sub> O <sub>2</sub> )	11.10 mno	18.76 f-i	22.91 cd	27.05 b	19.95 B
2% H <sub>2</sub> O <sub>2</sub>	10.33 no	15.87 ijk	20.59 def	22.84 cd	17.41 CD
2% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	9.63 no	12.13 lmn	17.33 g-j	19.72 efg	14.70 E
2% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	9.33 no	11.40 mno	15.69 ijk	18.57 f-i	13.75 EF
4% CaCl <sub>2</sub> + 1% H <sub>2</sub> O <sub>2</sub>	9.03 no	10.76 mno	14.58 jkl	16.85 g-j	12.80 FG
4% CaCl <sub>2</sub> + 2% H <sub>2</sub> O <sub>2</sub>	8.60 o	10.12 no	13.44 klm	15.70 ijk	11.96 G
Means	10.03 D	14.78 C	18.85 B	22.27 A	

Means followed by the same letters within pre-storage applications, storage periods and their interactions in each season are not significantly different at level  $P \leq 0.05$  according to DMRT.

seasons, respectively. On the contrary, this treatment had the highest TA (0.93 & 0.86 g citric acid/100 ml juice) in the first and second seasons, respectively. On the other hand, untreated guava fruits (control) recorded the highest fruit contents of TSS (11.08 & 11.27 °Brix) and TSS/TA ratio (19.26 & 22.29) in 2015 and 2016 seasons, respectively, and also recorded the lowest fruit content of TA (0.63 & 0.56 g citric acid/100 ml juice) in the first and second seasons, respectively.

The interaction effects between pre-storage treatments and storage periods showed significant difference at  $p \leq 0.05$  for ‘Etmany’ guava fruits contents of TSS, TA and TSS/TA ratio during the two seasons in this study.

Citric acid is the major organic acid in guava fruits, which is an important parameter in maintaining the quality of fruits and a rapid reduction in acidity hastened fruit senescence (Hiwale & Singh, 2003). The increase of TA as well as the decrease of TSS and TSS/TA ratio contents of ‘Etmany’ guavas dipping in CaCl<sub>2</sub>, H<sub>2</sub>O<sub>2</sub> and their combinations especially those treated with 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub> might be due to lowering respiration rate, ethylene production and hydrolytic enzymes as mentioned by Khandaker *et al.* (2012) and Reena (2016).

Thereby, these applications delayed ripening and physiological senescence of the fruits during storage as compared to the untreated fruits (control).

In addition, the progressive decline of guava fruit content in TA with the advancement of storage period storage might be due to utilization of organic acids in respiration process and conversion of acids into salts and sugars by the enzymes (Hiwale & Singh, 2003). On the other hand, the increase of guavas content in TSS with prolonging of storage period could be attributed to the hydrolysis of starch into sugars and an increase in water soluble galacturonic acids from the degradation of pectic substances by hydrolytic enzymes (Jain *et al.*, 2003). Whereas, slight decline of fruits content in TSS at the end of storage period due to utilization of soluble solids in respiratory processes (Bashir & Abu-Goukh, 2003).

These results are in agreement with the earlier reports of Hiwale & Singh (2003), Shaaban (2006), Kumar *et al.* (2012) and Reena (2016). They noted that soaking guava fruits in CaCl<sub>2</sub> before storage resulted in delaying the increase of fruit content in TSS and showed the higher flesh acid content as compared to the untreated fruits (control) during storage and

shelf life. Similarly, higher guava fruits content of TA was achieved by CaCl<sub>2</sub> application as compared to the control (Mahajan *et al.*, 2011; Phani Phani *et al.*, 2016 and Dohre, 2016). In addition, these authors mentioned that TSS increased during storage followed by a decline at the end of storage period, while TA decreased gradually and significantly with the advancement of storage period. In addition, our results fall in line with the findings of Dohre (2016) who mentioned that, treated guava fruits with CaCl<sub>2</sub> significantly delayed the increase of TSS/TA ratio during storage in comparison to untreated fruits, and this ratio increased with the advancement of storage period. Moreover, the same results were reported by Ismail *et al.* (2010) who reported that dipping 'Maamoura' guavas in 2% CaCl<sub>2</sub> or 2% H<sub>2</sub>O<sub>2</sub> four minutes individually or plus fumigation with lemon grass oil delayed the increase of fruit content in TSS as compared to the untreated fruits during cold storage at 8°C for 15 days. In addition, these results are in accordance with those reported by Mohamed *et al.* (2016) who claimed that, dipping 'Valencia' oranges in 2% H<sub>2</sub>O<sub>2</sub> for five minutes significantly slowed the increase of TSS and TSS/TA ratio maintained TA than the control during cold storage at 8°C for fifteen weeks. Furthermore, fruit contents of TSS and TSS/TA ratio increased with the progress of storage period, while TA decreased.

#### **Conclusion**

Generally, the experiment conducted here indicated that, the pre-storage application of 2 or 4% CaCl<sub>2</sub> and 1 or 2% H<sub>2</sub>O<sub>2</sub> individually or in combinations of 'Etmany' guavas significantly reduced the deterioration of physical and chemical characteristics of fruits as compared to the control treatment during cold storage and shelf life. Dipping 'Etmany' guava fruits in 4% CaCl<sub>2</sub> plus 1 or 2% H<sub>2</sub>O<sub>2</sub> for five minutes before storage are the promising methods for delaying ripening and senescence processes of fruits. Furthermore, these applications will suppress postharvest deterioration of external and internal fruit quality as well as extend the storage life of this cultivar up to 21 days at 8°C plus two days shelf life at ambient temperature (18-23°C).

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تأخير تدهور ثمار الجوافة الشتوية أثناء التخزين باستخدام معاملات ما بعد الحصاد  
بكلوريد الكالسيوم وفوق أكسيد الهيدروجين

محمود على أحمد محمد - \*أحمد فتحي عبد الخالق

معهد بحوث البساتين - مركز البحوث الزراعية - مصر.  
\* قسم البساتين - كلية الزراعة - جامعة طنطا - طنطا - مصر.

**ملخص**

ثمار الجوافة من ثمار الفاكهة عالية التلف ولها عمر تسويقي قصير نسبياً بعد الحصاد. أجريت هذه التجربة في موسمي 2015 و 2016 لتقييم تأثير كل من كلوريد الكالسيوم وفوق أكسيد الهيدروجين والدمج بينها بعد الحصاد على صفات جودة ثمار الجوافة الشتوية، سلالة "عثماني"، أثناء التخزين. تم تخزين كل المعاملات على درجة  $8 \pm 1$  درجة مئوية و  $90 \pm 5$  % رطوبة نسبية لمدة 21 يوم يعقبها يومين لتقييم العمر التسويقي في الظروف البيئية (18-23 درجة مئوية و 55-65% رطوبة نسبية). تم تقدير التغيرات في الخواص الطبيعية والكيميائية للثمار على فترات أسبوعية أثناء التخزين المبرد يعقبها يومين فترة عمر تسويقي. خفضت كل الثمار المعاملة بشكل كبير التدهور في الخصائص الفيزيائية والكيميائية لثمار الجوافة الشتوية، سلالة "عثماني" مقارنة بالثمار غير المعاملة (المعاملة القياسية). إضافة إلي ذلك، كانت معاملة ثمار الجوافة سلالة عثماني بكلوريد الكالسيوم بتركيز 2 أو 4% بالاشتراك مع فوق أكسيد الهيدروجين بتركيز 1 أو 2% متفوقة في تأخير تدهور جودة الثمار أثناء التخزين وذلك بالمقارنة مع الثمار المعاملة بصورة منفردة وغير المعاملة. قللت هذه المعاملات بشكل معنوي من فقدان الوزن وخفضت التلف الحادث و عملت علي زيادة النسبة المئوية للثمار القابلة للتسويق وحافظت على المظهر الجيد للثمار كما قللت أيضاً من فقد في قيم الصلابة وزاوية اللون والللمعان. أبطأت أيضاً هذه المعاملات بشكل معنوي الزيادة في محتويات الثمار من المواد الصلبة الذائبة الكلية ونسبة المواد الصلبة الذائبة الكلية إلى الحموضة المقدره كما خفضت أيضاً بشكل معنوي من معدل تدهور محتويات الثمار من فيتامين سي والحموضة المقدره أثناء فترة التخزين. علاوة على ذلك، كانت المعاملات التطبيقية لثمار الجوافة قبل التخزين باستخدام 4% كلوريد كالسيوم بالاشتراك مع 1 أو 2% فوق أكسيد الهيدروجين كانت هي الأكثر فعالية في هذا التأثير بالمقارنة مع الثمار الأخرى المعاملة وغير المعاملة (المعاملة القياسية). لذا، تعتبر هذه المعاملات التطبيقية طرق فعالة وواعدة لتأخير عمليات النضج والشيوخوخة بالإضافة إلي تأخير تدهور جودة ما بعد الحصاد لثمار الجوافة الشتوية سلالة "عثماني" وذلك أثناء التخزين المبرد علي 8 درجة مئوية لفترة تصل إلى 21 يوماً يعقبها يومين للتسويق علي 18-23 درجة مئوية.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (69) العدد الاول (يناير 2018):115-130.