EFFECT OF POSTHARVEST OZONE TREATMENT ON BROWNING, PPO ENZYME ACTIVITY AND QUALITY OF SEEDY GUAVA FRUITS HARVESTED AT TWO MATURITY STAGES

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ABSTRACT

The present study was carried out during 2009 and 2010 seasons on seedy guava fruits(greenish-yellow and full-yellow skin color) to investigate the effects of ozone treatment (150ppb) and the subsequent cold storage (10±1°C) on the physico-chemical fruit properties.

Ozone treated fruits were free from any chilling injury symptoms and had good appearance, flavour and eating quality compared to the untreated fruits. Ozone treatment insignificantly increased fruit weight loss in both seasons. Ozone had significant effect on delaying changes in guava skin color. So, the treated fruits had significant higher skin hue° values compared to untreated ones and the full-yellow fruits were more affected. Ozone significantly reduced each of soluble solid content (SSC) changes and the loss of flesh firmness, citric acid and Vitam.C values. Ozone treatment had clear effect on decreasing polyphenol oxidase (PPO) activity of fruit skin and flesh.

Keywords: Ozone, postharvest, cold storage, seedy guava fruits, *Psidium guajava*, physico-chemical properties.

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INTRODUCTION

Guava (*Psidium guajava* L.) is a tropical fruit, widely consumed fresh and also processed. It is a good source of Vitam. C where it contains almost five times as much as Vitam. C as oranges (Ashaye *et al.,* 2005). Guava pulp and peel showed high content of dietary fiber (48.55–49.42%) and extractable polyphenols (2.62–7.79%) which is correlated with a remarkable antioxidant activity (Escrig *et al.,* 2001). Guava fruits are very perishable, delicate to handle and starts to deteriorate quickly during marketing or storage unless consumed or processed.

Guava are harvested seasonally and are subsequently subject to ripening, senescence, microbial and pests infestation, water loss, anatomical, morphological and compositional changes. Therefore, the development of adequate postharvest treatments for fruits is of great necessity and economic importance. Ozone has excellent ability to reduce microbial populations and does not leave a residue, so its postharvest use is increasing (Parish *et al.,* 2003). For postharvest treatment of fresh fruits and vegetables, ozone can be used as a relatively brief pre-storage or storage treatment in air or water, or as a continuous or intermittent component of the atmosphere throughout storage or transportation. Both procedures have recently received considerable commercial interest, especially because of the lack of residues in the product and the new regulatory issues (Palou *et al.,* 2002). The use of ozone as a phytosanitary and germicidal agent had been reported on apples (Gooch, 1996), strawberries and peaches (Ridley and Sims, 1996), pears (Spotts and Cervantes, 1992), mangos (Martínez *et al.,* 2002; El-Saedy *et al.*, 2011), peaches and grapes (Palou *et al.,* 2002).

The present work was planned to investigate the effects of ozone treatment and the associated cold storage on the physico-chemical changes of seedy guava fruits harvested at two maturity stages.

MATERIALS AND METHODS

The present investigation was carried out during 2009 and 2010 seasons in Complete Randomize Design on seedy guava fruits cultivated in a private orchard in El-Maamoura, Alexandria Governorate. Guava fruits were harvested during the first days of October at two maturity stages; greenish-yellow and full-yellow skin color, then immediately transported to the Postharvest Center of Horticultural

Crops, Faculty of Agriculture, Alexandria University. Guava fruits were carefully sorted to eliminate fruits with any obvious mechanical damage or defect, and then were backed in one layer of twelve carton boxes (each contained 16-20 fruits). Each of the above stages was divided into two groups, one of them was exposed to 150 ppb ozone (O_3) during storage by using ozone generator (biofresh OZ80, UK), the other fruit group was untreated. All fruits were stored at 10±1°C and 85-90±5 % relative humidity. Fifteen guava fruits were taken to determine its initial physico-chemical properties (Table 1). Changes in such properties were followed up every five days throughout the experimental working period.

Three groups of five fruits for each were labeled in each treatment and the initial weight of every fruit was recorded. Subsequent periodical weight determinations were carried out and the weight loss percentage of each fruit was calculated in relation to its original weight and the average weight loss percent was calculated for each treatment.

External color of the fruits was estimated visually and measured on four points of each fruit by Minolta Chroma meter CR-200-Japan. a* and b* values were used to calculate the hue angle (hue°) to follow the skin color changes during the experiment period according to the following equation: Hue°= arctan (b*/a*) (Sancho *et al.*, 2010). Hue° is a quantitative to expression of color and represents the changes in fruit color (0 = red, 90 = yellow, 180 = green, and 270 = blue).

Guava fruit firmness was determined for the peeled two opposite sides of each given fruit in the sample by using the Effegi pressure tester with an eight mm plunger (Effegi, 48011 Alfonsine, Italy).

Three samples of three fruits in each treatment were squeezed and used to determine the percentage of SSC by using a hand refractometer and the percentage of titratable acidity as g citric acid /100 ml of fruit juice (Chen and Mellenthin, 1981). Vitamin C as mg ascorbic acid /100 ml was also determined in fruit juice by titration with 2,6 dichlorophenol – indophenol solution in the presence of oxalic acid solution (AOAC, 1980).

Polyphenol oxidase (PPO) enzyme activity of fruit skin and flesh were determined in the crude extract (Brenneman and Black, 1979)

Table 1. The initial quality of seedy guava fruits during 2009 and 2010 seasons

Parameter	2009		2010	
	Greenish-yellow	Full-yellow	Greenish-yellow	Full-yellow
Weight (gm)	226.00	217.53	201.02	216.13
Length (cm)	8.83	8.23	8.00	8.77
Breadth (cm)	7.23	7.40	7.13	7.23
Firmness (lb/in^2)	12.00	8.22	11.86	8.18
SSC (%)	9.07	9.60	8.13	9.87
Acidity (%)	0.47	0.45	0.48	0.36

of three samples of each treatment. The activity of PPO was measured using the method of Matta and Dimond (1963).

The termination of the experiment was done with the browning incidence and when fruits firmness reached the average of 3 lb/in^2. The obtained data were statistically analyzed according to the methods described by Snedecor and Cochran (1980). The individual comparisons were carried out using the Least Significant Difference (LSD) according to SAS Institute (1997). Simple regression coefficient (r^2) between storage period and studied properties was calculated using SAS program (1997).

RESULTS AND DISCUSSION

Chilling Injury Incidence

The typical chilling injury (CI) symptoms in guava fruit include surface pitting, water soaked lesions and skin and flesh discoloration with the decay incidence on the chilled areas (Singh and Pal, 2008). In the current study, the CI symptoms began to appear (Fig. 1-A) on the untreated full-yellow fruits after 10 days of cold storage as brown surface pitting which became larger (Fig. 1-B) and turned to water soaked areas (Fig. 1-C). Those areas were suitable media for decay incidence (Fig. 1- D).

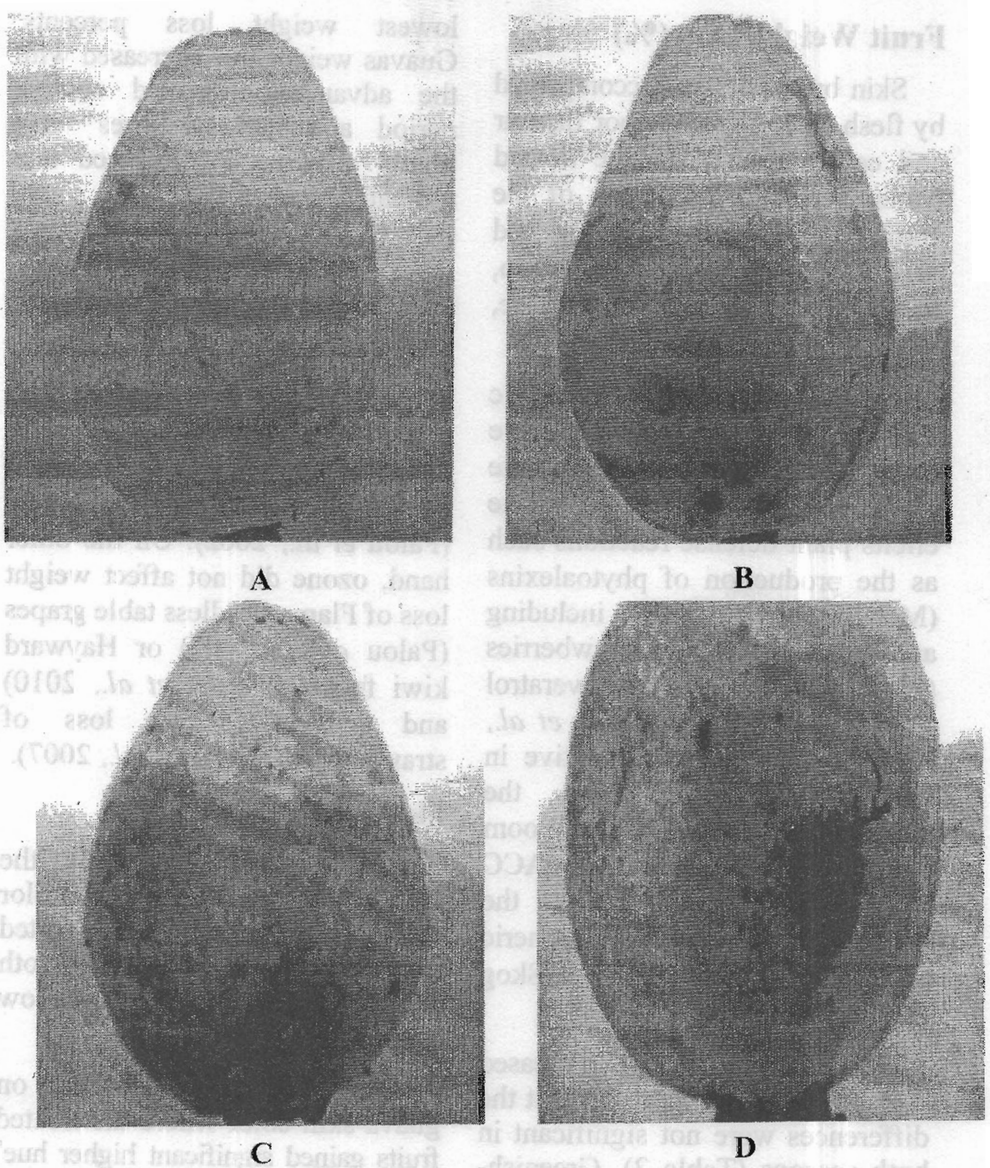

Fig. 1. Chilling injury symptoms in seedy guava stored at 10°C

Fruit Weight Loss (%)

Skin browning was accompanied by flesh softening and poor flavour and eating quality. Ozone treated fruits were free from any of the above symptoms even by the end of cold storage after 15 days. So, the fruits had good appearance, flavour and eating quality.

Ozone acts as potent phytotoxic agent due to its high oxidative capacity and its ability to generate toxic molecular species. Ozone elicits plant defense reactions such as the production of phytoalexins (Maharaj *et al.*, 1999), including ascorbic acid in strawberries (Pérez *et al.*, 1999) and resveratrol in grapes (González-Barrio *et al.*, 2006). Also, O_3 was effective in removing ethylene from the atmosphere of the storage room due to the reduction in ACC ethylene precursor or due to the oxidation of the atmospheric ethylene (Jin *et al.*, 1989 and Skog and Chu, 2001).

Ozone treatment increased weight loss of guava fruits, but the differences were not significant in both seasons (Table 2). Greenish-yellow fruits had higher percents of weight loss than full-yellow ones (not significant differences). In the 5th and 10th day intervals, untreated full-yellow fruits had the lowest weight loss percents. Guavas weight loss increased with the advancing of cold storage period and the r^2 values were highly significant in treated and untreated fruits.

The above results of ozone on fruit weight loss agree with Palou *et al.* (2002) on Zee Lady' peaches and El-Saedy *et al.* (2011) on Kent mangos. The ozone effect on weight loss increase may be as a result of cuticle and/or the epidermal tissue damage by ozone (Palou *et al.*, 2002). On the other hand, ozone did not affect weight loss of Flame Seedless table grapes (Palou *et al.*, 2002) or Hayward kiwi fruits (Barboni *et al.*, 2010) and reduced weight loss of strawberries (Allende *et al.*, 2007).

Skin Color (hue°)

Data in Table 3 show the tendencies of external color changes as hue° of ozone treated and untreated guava fruits of both greenish-yellow and full-yellow fruits.

Ozone had significant effect on guava skin color where the treated fruits gained significant higher hue° values compared by untreated ones. Ozone was more effective on full-yellow fruits where the differences were not significant for greenish-yellow fruits in the first two intervals

Table 2. Effect of ozone treatment on weight loss (%) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	0.00a	3.03a	5.49a	7.58a	4.03	0.993**
	0	0.00a	2.49ab	4.51ab	6.71a	3.43	0.998**
	Mean	0.00	2.76	5.00	7.15	3.73	
Full-yellow	150	0.00a	2.39ab	4.97ab	6.63a	3.50	0.992**
	0	0.00a	1.91b	2.97b	4.64a	2.38	0.989**
	Mean	0.00	2.15	3.97	5.64	2.94	
		Second season (2010)					
Greenish-yellow	150	0.00a	2.43a	4.81a	6.10a	3.34	0.983**
	0	0.00a	2.33a	3.99a	5.47a	2.95	0.988**
	Mean	0.00	2.38	4.40	5.79	3.15	
Full-yellow	150	0.00a	1.83a	3.49a	4.73a	2.51	0.993**
	0	0.00a	1.90a	3.09a	4.96a	2.49	0.993**
	Mean	0.00	1.87	3.29	4.85	2.50	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.

*; Significant at 0.05%. **; Significant at 0.01%.

Table 3. Effect of ozone treatment on skin color (hue°) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	109.11a	102.40a	90.26a	81.90a	95.92	0.989**
	0	109.11a	99.40a	87.28a	72.06bc	91.96	0.990**
	Mean	109.11	100.90	88.77	76.98	93.94	
Full-yellow	150	96.54b	96.69a	95.27a	77.09ab	91.40	0.652
	0	96.54b	80.88b	71.46b	67.52c	79.10	0.931*
	Mean	96.54	88.79	83.37	72.31	85.25	
		Second season (2010)					
Greenish-yellow	150	102.87a	102.42a	90.98a	81.74a	94.50	0.909*
	0	102.87a	96.73a	80.88b	70.57bc	87.76	0.975*
	Mean	102.87	99.58	85.93	76.16	91.13	
Full-yellow	150	96.72a	93.56a	78.62b	77.27ab	86.54	0.891
	0	96.72a	80.72b	68.17c	67.73c	78.34	0.885
	Mean	96.72	87.14	73.40	72.50	82.44	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.

*; Significant at 0.05%. **; Significant at 0.01%.

in 2009 season and through the first interval in 2010 season. The previous data of ozone on maintaining fruit color agree with those of Skog and Chu (2001); Shalluf *et al.* (2007) and El-Saedy *et al.* (2011). All skin hue° values decreased with the advancing of cold storage period and the r^2 values were greater in greenish-yellow fruits. Same results were obtained by Sinuco *et al.* (2010) on pink and white guava fruits and Hernandez *et al.* (2009) on araza (similar to guava) fruits.

Fruit Flesh Firmness (lb/in^2)

At harvest, the greenish-yellow fruits had the initial flesh firmness values of 11.93 and 11.60 lb/in^2 in 2009 and 2010 seasons, respectively. The corresponding values for full-yellow fruits were 8.45 and 8.00 lb/in^2, respectively (Table 4). After five days of cold storage at 10°C, greenish-yellow fruits lost 56.17 and 49.74% of their initial values in 2009 and 2010 seasons, respectively. However, full-yellow fruits lost lower percentages (44.73 and 34.63%, respectively). These percentages were lower with ozone treatment where the greenish-yellow fruits lost 44.68 and 42.50% and the full-yellow ones lost 34.91 and 33.38% in both seasons, respectively. The effect of ozone treatment on reducing flesh firmness loss was significant by the end of cold storage period where the ozone treated fruits had significant higher flesh firmness compared by control fruits. The significant r^2 values reflected the decrease in flesh firmness of both stages with the progress of storage period.

The previous results are in line with those of Aguayo *et al.* (2006) and Tzortzakis *et al.* (2007) on tomatoes, Allende *et al.* (2007) on strawberries, Salvador *et al.* (2006) on persimmons and El-Saedy *et al.* (2011) on mangos. While Barboni *et al.* (2010) recorded no significant effect of ozone on kiwi fruits firmness. The mechanisms underlying the effects of ozone on fruit firmness remain to be ascertained, but it is known that cell wall matrices, especially pectins, undergo disruption during fruit ripening and these modifications that are believed responsible for the decrease in tissue firmness that accompanies ripening (Tucker and Greison, 1987). Pectins are degraded during ripening undergo both solubilization and depolymerization (Seymour *et al.*, 1990). Ozone reacts rápidly with ethylene, and for those commodities that benefit from ethylene removal during storage ozone is considered a potential tool to extend storage life with the added advantage of controlling disease proliferation (Jin *et al.*, 1989; Aguayo *et al.*, 2006; Salvador *et al.*, 2006; Tzortzakis *et al.*, 2007).

Soluble Solids Content (SSC%)

The fruits of full-yellow guava had significantly higher SSC percentages than the greenish-yellow ones especially in the second season (Table 5). Ozone reduced the SSC changes during the first 10 days where the treated fruits had higher contents, but without significant differences. At the end of cold storage period, ozone treated fruits had significant higher SSC values in both greenish-yellow and full-yellow fruits in both seasons. Ozone slowed the changes of SSC and maintained it high by the end of the storage period due to its effect on delaying ripening processes. Those results agree with the results of Tzortzakis *et al.* (2007) and El-Saedy *et al.* (2011). On the other hand, Salvador *et al.* (2006); Shalluf *et al.* (2007) and Barboni *et al.* (2010) reported lower SSC values of O_3 treated fruits, while Whangchai *et al.* (2010) found no significant effect of O_3 treatment on SSC.

Titratable Acidity (%)

It is obvious from Table 6 that the greenish-yellow fruits had higher citric acid contents (0.47 and 0.48%) compared to the full-yellow ones (0.45 and 0.36%) in both seasons, respectively. Ozone significantly affected the fruit citric acid content, since the treated guavas maintained their acidity higher than the untreated ones. Barboni *et al.* (2010) and El-Saedy *et al.* (2011) observed significant effect of O_3 on maintaining acidity contents, whereas, Tzortzakis *et al.* (2007) and Whangchai *et al.* (2010) reported insignificant effect.

Guava fruits lost their acidity contents with the progress of the storage period. Untreated greenish-yellow fruits lost 46.81 and 50.00% of its initial values after 15 days and the full-yellow fruits lost 57.78 and 50.00% in the first and the second seasons, respectively. Those losses percentages were lower in the treated fruits, whereas the greenish-yellow guavas lost 44.68 and 45.83% and the full-yellow ones lost 46.67 and 33.33% in the two seasons, respectively. Citric acid is a respiratory substrate and its consumption in respiration increased with the progress of storage period (Chandra *et al.*, 1994 on Allhabad Safeda guavas; Zaghloul, 1997 on seedy guavas; Bashir and Abu-Goukh, 2002 on white and pink fleshed guavas).

Table 4. Effect of ozone treatment on flesh firmness (lb/in^2) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	11.93a	6.60a	4.67a	3.97a	6.79	0.856
	0	11.93a	5.23b	4.33ab	2.73b	6.06	0.825
	Mean	11.93	5.92	4.50	3.35	6.43	
Full-yellow	150	8.45b	5.50ab	4.50ab	3.17ab	5.41	0.939*
	0	8.45b	4.67b	3.97b	1.77c	4.72	0.928*
	Mean	8.45	5.09	4.24	2.47	5.07	
		Second season (2010)					
Greenish-yellow	150	11.60a	6.67a	5.43a	4.33a	7.01	0.861
	0	11.60a	5.83a	4.67ab	2.93b	6.26	0.872
	Mean	11.60	6.25	5.05	3.63	6.64	
Full-yellow	150	8.00b	5.33a	4.93ab	3.37b	5.41	0.919*
	0	8.00b	5.23a	4.10b	1.90c	4.81	0.977*
	Mean	8.00	5.28	4.52	2.64	5.11	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.
*; Significant at 0.05%. **; Significant at 0.01%.

Table 5. Effect of ozone treatment on SSC (%) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	9.07a	8.60a	9.87a	9.93a	9.37	0.595
	0	9.07a	8.33a	9.40a	8.93b	8.93	0.035
	Mean	9.07	8.47	9.64	9.43	9.15	
Full-yellow	150	9.60a	9.53a	9.73a	9.40b	9.57	0.141
	0	9.60a	8.80a	9.67a	8.20c	9.07	0.377
	Mean	9.60	9.17	9.70	8.80	9.32	
		Second season (2010)					
Greenish-yellow	150	8.13b	8.67b	9.60ab	9.67ab	9.02	0.887
	0	8.13b	8.13b	8.87b	8.20c	8.33	0.116
	Mean	8.13	8.40	9.24	8.94	8.68	
Full-yellow	150	9.87a	8.73b	10.07a	9.73a	9.60	0.017
	0	9.87a	9.80a	9.87a	9.07b	9.65	0.079
	Mean	9.87	9.27	9.97	9.40	9.63	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.
*; Significant at 0.05%. **; Significant at 0.01%.

Table 6. Effect of ozone treatment on citric acid content (%) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	0.47a	0.36a	0.34a	0.26a	0.36	0.940*
	0	0.47a	0.28b	0.28bc	0.25a	0.32	0.712
	Mean	0.47	0.32	0.31	0.26	0.34	
Full-yellow	150	0.45a	0.33ab	0.31ab	0.24a	0.33	0.923*
	0	0.45a	0.27b	0.25c	0.19b	0.29	0.851
	Mean	0.45	0.30	0.28	0.22	0.31	
		Second season (2010)					
Greenish-yellow	150	0.48a	0.31a	0.26a	0.26a	0.33	0.771
	0	0.48a	0.29a	0.25a	0.24b	0.32	0.766
	Mean	0.48	0.30	0.26	0.25	0.33	
Full-yellow	150	0.36b	0.30a	0.26a	0.24b	0.29	0.952*
	0	0.36b	0.21b	0.24a	0.18c	0.25	0.696
	Mean	0.36	0.26	0.25	0.21	0.27	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.
*; Significant at 0.05%. **; Significant at 0.01%.

Vitamin C Content (mg ascorbic acid/100 ml fruit juice)

The initial values of Vitam. C (Table 7) showed that greenish-yellow guavas had lower contents (124.40 and 120.10 mg/100ml juice, compared to the full-yellow fruits which contained 132.93 and 139.77 mg/100ml juice in 2009 and 2010 seasons, respectively. Ozone treatment had clear effect on maintaining the fruit Vitam. C content and reducing its loss during cold storage. This effect was significant in five and 15 day intervals in both seasons.

The previous results are in agreement with Pérez *et al.* (1999) and Allende *et al.* (2007) on strawberries; Aguayo *et al.* (2006) on tomatoes and El-Saedy *et al.* (2011) on mangos. Vitam. C is able to scavenge oxygen radicals and avoid oxidative stress (Klopotek *et al.*, 2005). Thus, changes in Vitam. C of O_3-treated fruits could be attributed to the activation of an antioxidative system that promotes biosynthesis of Vitam. C from the carbohydrate pool (Pérez *et al.*, 1999). On the other hand, Shalluf *et al.* (2007), Tzortzakis *et al.* (2007) and Barboni *et al.* (2010) reported insignificant changes in Vitam. C due to O_3 treatment.

Guava fruits of both ripening stages lost their Vitam. C contents

Table 7. Effect of ozone treatment on V.C content (mg/100 ml juice) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	124.40a	119.81a	110.65a	96.93a	112.95	0.953*
	0	124.40a	88.87a	72.21b	54.00b	84.87	0.964*
	Mean	124.40	104.34	91.43	75.47	98.91	
Full-yellow	150	132.93a	114.64a	105.75a	92.33a	111.41	0.982**
	0	132.93a	88.42a	60.43b	50.25b	83.01	0.928*
	Mean	132.93	101.53	83.09	71.29	97.21	
		Second season (2010)					
Greenish-yellow	150	120.10b	125.75a	120.87a	112.26a	119.75	0.431
	0	120.10b	80.43ab	81.31b	64.33b	86.54	0.822
	Mean	120.10	103.09	101.09	88.30	103.15	
Full-yellow	150	139.77a	113.64ab	111.08a	96.67a	115.29	0.900
	0	139.77a	71.09b	55.99b	46.83b	78.42	0.812
	Mean	139.77	92.37	83.54	71.75	96.86	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.
*; Significant at 0.05%. **; Significant at 0.01%.

with the increasing of cold storage period. The highest loss percentages were reported for untreated full-yellow fruits (62.20 and 66.49% Vitam. C loss in 2009 and 2010 seasons, respectively) compared to the untreated greenish-yellow (56.59 and 46.44%). The treated full-yellow fruits lost 30.54 and 30.84%, while the treated greenish-yellow ones lost 22.08 and 6.53% only of Vitam. C during 2009 and 2010 seasons, respectively. The loss in Vitam. C could be attributed to rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L-ascorbic acid oxidase (Bhullar and Farmahan, 1980; Rofael, 1985; Zaghloul, 1997 and Bashir and Abu- Goukh, 2002).

Peel and Flesh PPO Activities (O.D.)

Initially, full-yellow guava fruits contained higher peel (Table 8) and flesh (Table 9) PPO activities than the greenish-yellow ones. Ozone treatment had clear effect on decreasing PPO activities. The differences were significant for full-yellow fruits (fruit peel and flesh in most intervals in both seasons) compared to untreated fruits. The present results consistent with the studies of Whangchai *et al.* (2006) on longan fruits and El-Saedy *et al.* (2011) on mango fruits.

Table 8. Effect of ozone treatment on peel PPO activity (O.D.) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	0.036b	0.017c	0.020b	0.033b	0.027	0.007
	0	0.036b	0.022bc	0.030b	0.038b	0.032	0.063
	Mean	0.036	0.020	0.025	0.036	0.030	
Full-yellow	150	0.074a	0.025b	0.033b	0.040b	0.043	0.317
	0	0.074a	0.038a	0.054a	0.063a	0.057	0.021
	Mean	0.074	0.032	0.044	0.052	0.050	
		Second season (2010)					
Greenish-yellow	150	0.040b	0.022c	0.028c	0.032b	0.031	0.095
	0	0.040b	0.023bc	0.032bc	0.036b	0.033	0.003
	Mean	0.040	0.023	0.030	0.034	0.032	
Full-yellow	150	0.069a	0.026b	0.034b	0.040b	0.042	0.296
	0	0.069a	0.036a	0.056a	0.069a	0.058	0.027
	Mean	0.069	0.031	0.045	0.055	0.050	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.

*; Significant at 0.05%. **; Significant at 0.01%.

Table 9. Effect of ozone treatment on flesh PPO (O.D.) of cold stored guava fruits in 2009 and 2010 seasons

Maturity stage	Ozone (ppb)	Storage period (days) 0	5	10	15	Mean	r^2
		First season (2009)					
Greenish-yellow	150	0.005b	0.012b	0.013c	0.014c	0.011	0.784
	0	0.005b	0.014b	0.016b	0.016bc	0.013	0.740
	Mean	0.005	0.013	0.015	0.015	0.012	
Full-yellow	150	0.014a	0.014b	0.018b	0.018b	0.016	0.800
	0	0.014a	0.018a	0.022a	0.020a	0.019	0.691
	Mean	0.014	0.016	0.020	0.019	0.018	
		Second season (2010)					
Greenish-yellow	150	0.007b	0.010c	0.012b	0.014b	0.011	0.989**
	0	0.007b	0.016a	0.018a	0.018a	0.015	0.740
	Mean	0.007	0.013	0.015	0.016	0.013	
Full-yellow	150	0.012a	0.013b	0.019a	0.018a	0.016	0.731
	0	0.012a	0.019a	0.020a	0.019a	0.018	0.590
	Mean	0.012	0.016	0.020	0.019	0.017	

Means within columns (in same season) having a common letter are not significantly different. r^2 =Determination coefficient.

*; Significant at 0.05%. **; Significant at 0.01%.

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تأثير المعاملة بالأوزون بعد الجمع على التلون البنى ونشاط أنزيم البولي فينول أوكسيديز وجودة ثمار الجوافة البذرية خلال التخزين المبرد

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أجريت هذه الدراسة خلال موسمي ٢٠٠٩ و ٢٠١٠ م على ثمار الجوافـة البذريـة (الأصفر المخضر و الأصفر (كاملة التلوين)) لدراسة تأثير المعاملة بالأوزون (١٥٠ جـزء في البليون) و التخزين المبرد (١٠ ± ١°م) على الخواص الفسيوكيمائية للثمار.

خلت الثمار المعاملة بالأوزون من أضرار التبريد و اكتسبت مظهراً و نكهة و جـودة أكلية أفضل كما أدت المعاملة بالأوزون إلى زيادة غير معنوية في معـدل الفقـد فـي وزن الثمار خلال موسمي الدراسة، وكان لمعاملة الأوزون تأثير معنوى فى تأخير تغيرات لـون الثمار الخارجي و قد تأثرت الثمار الصفراء بدرجة أكبر، كما قللت المعاملة بالأوزون مـن تغيرات المواد الصلبة الذائبة، والفقد في كل من صلابة اللحم وحامض الستريك وفيتامين ج معنوياً وكان لمعاملة الأوزون تأثير واضح فى تقليل نشاط إنزيم البولي فينـول أوكسـيديز خاصة في الثمار كاملة التلوين.