J. Plant Production, Mansoura Univ., Vol. 3 (5): 857 - 876, 2012

TREATMENTS TO INCREASE STORABILITY AND MARKETABILITY OF GUAVA (*Psidium guajava* L.) FRUITS

Samaan, L. G.; M. A. Iraqi; L. A. Arafat and Tayseer A. A. Serag
Pomology Dept., Faculty of Agriculture, Mansoura University, Egypt.

ABSTRACT

The plant material in the current study in two successive seasons of 2007 and 2008 was guava fruits harvested from fruiting trees pre-harvest, 10 days to harvest date, sprayed with tap water (TW) to serve as control or with vitamin B_{12} solution either at 0.3 or 0.6 mg.L $^{-1}$ The harvested fruits were immediately transported to the laboratory, thoroughly washed with tap water and soap to remove impurities on the fruit surfaces. These fruits were cold stored for 30 days at 8±1^{o}C and 80-85% RH after soaked in tap water (control) or in Ca Cl_2 solution either at 1.5 or 3.0% for 15 min.

Fruits during cold storage period were subjected to periodical measurements of 3 physical and 6 chemical characteristics at 6-day-intervals to measure changes of these characteristics throughout cold storage period. The obtained results revealed that factors affected the behavior of guava fruit characteristics during cold storage period were differed due to the measured characteristic. Fruits of the "T9"treatment (pre-harvest sprayed trees with vitamin B_{12} solution at 0.6 mg.L^{-1} plus post-harvest soaked the harvested fruits in Ca Cl_2solution at 3.0% for 15 min as well as stored at 8±1^{o}C and 80-85% RH) recorded the best quality at the end of storage period. They measured the highest firmness, vitamin C, total soluble sugars and total phenols along with the least fruit weight loss%. On the other hand, the least acidity% found in fruit juice of "T4" treatment (Pre-harvest sprayed trees with vitamin B_{12} at 0.3 mg.L^{-1}). The same treatment plus soaked the harvested fruits in Ca Cl_2 at 1.5% or 3.0% (T5 and T6) were the best ones to keep TSS% and TSS/acid ratio at the higher level at the end of cold storage period.

INTRODUCTION

Guava (*Psidium guajava* L.) is an important fruit crop of the tropical and subtropical regions in the world (Chopda and Barrett, 2001). Its fruits vary in size, shape, flavor and extolled for delicious taste. The fruit contains 74-87% moisture, 13-26% dry matter, 0.5-1.0% ash, 0.4-0.7% fat and 0.8-1.5% protein (Chin and Young, 1980). In addition, it is rich in vitamin C and a fair amount of vitamin A and some vitamin B. As for minerals, it also contains a little amount of phosphorous, calcium, iron, potassium and sodium (Lim and Khoo, 1990). Otherwise, it is very perishable, delicate in nature, short post-harvest life and susceptibility to chilling injury and diseases. Consequently, poor handling practices and inappropriate storage facilities along with certain post-harvest constraints limit its long duration storage and transportation which in turn is limited the potential for commercialization of guava fruit.

Research in tropical fruits has shown that internal and external disorders are directly related to fruit calcium levels. Tissues high in calcium have stronger cell walls, are firmer and resist infection more readily. Otherwise, lack of adequate calcium leads to browning of tissues. This can occur due to membranes become less stable. At the same time, calcium may act to chelate phenols and prevent their oxidation (kirkly and Pilbeam, 1984; Poovaiah *et al.,* 1988).Researches of pre- and post-harvest applied calcium were carried out by Van Reusburg and Engelbracht, (1986) on avocado fruits. They found that fruits of calcium lack measured lower rates of respiration and ethylene production. Consequently, give better fruit quality, change in ripening times and decrease the level of components responsible for fresh fruit. In the same line, Mehaisen, (2005) reported that improving fruit quality and storability were affected by pre- and post-harvest treatments especially with 0.5% Calcium salt. Such treatments raise starch by 3.0% and reduce decay and weight losses. More recent, Singh *et al.,* (2007) and Rajput *et al*., (2008) came to a similar result also with guava fruits. They indicated that calcium compounds at certain concentrations significantly succeeded to prolonging the storage life and post-harvest dipping was proved the better.

The recent findings pointed to antioxidant activity that interfering with keeping post-harvest quality and extending shelf life in climacteric fruits such as guava, mango and others (Conner *et al*., 2002; Zheng and Wang, 2003). The role of antioxidants is to neutralize free radicals by denoting an electron to them, pre-empting the electron theft that can cascade into cell damage and get a chance to harm the fruit. Recent evidence indicated that vitamin B compounds can be played a significant role as antioxidants in plants. Among these compounds is vitamin B_{12} which is called cobalamin. Higher plants neither synthesize nor require it because they contain cobalamin-independent methioninesynthase (Smith, *et al*., 2007). Vitamin B_{12} is important as co-factor for characterization of certain enzymes required in all organisms for formation of a large number of biological substances including the de novo of biosynthesis of amino acid methionine and regeneration of methyl group for methylation reactions (Elchel *et al*., 1995). Its sufficient works in close participation with others loading (folate) in the synthesis of building blocks for DNA and RNA synthesis, de novo synthesis of purine nucleotide which are involved in the synthesis of proteins along with carbohydrate and fat metabolism as well as necessary for normal cell division (Conner *et al*., 2002).

Although many experiments on antioxidants have been reported in apples and berries, however a few are reported on tropical fruits (Conner *et al*., 2002; Wolfe *et al*., 2003; Zheng and Wang, 2003). Ascorbic acid activity was the aim of studies carried out by Smirnoff, (1996); Lee and Kader, (2000). They explained its role in plants as protective factor against reactive oxygen species that are formed from photosynthetic and respiratory processes, linked to cell during growth and division and acting as a co-factor for many enzymes. Kondo *et al*., (2002) working on three apple cultivars and Cao *et al*., (2009) with loquat fruits correlated between antioxidant activity in fruit and its growth and quality.

According to this important correlation between either calcium or antioxidant levels in fruit and its growth and quality along with little has been done to address that in guavas, the present study was set up to add an evidence for this relationship through examining the effect of nine treatments including pre-harvest spraying trees with antioxidant solution either alone or plus post-harvest soaked the harvested fruits in calcium chloride solution. Post-harvest behavior of certain important physical and chemical characteristics and storability during cold storage were considered.

MATERIALS AND METHODS

Plant materials

Guava (*Psidium guajava* L.) fruits of a local commercial cultivar were obtained from a private guava orchard located at Damietta province, Damietta governorate, Egypt. Skin color is considered the best indicator of harvest maturity in guava fruit (Mercado-Silva *et al.,* 1998). Therefore, fruits having green yellowish skin color were harvested from trees at 7-year-old grown in sandy soil, planted 4x5 meters apart, received irrigation and fertilization programs along with other agriculture practices as recommended by Egyptian Agriculture Ministry to sandy soil conditions like this region. The selected trees almost were uniform and apparently diseases free, at two trees per treatment. The studied treatments can be explained as follows:

(T1) At pre-harvest, trees sprayed with tap water and post-harvest the harvested fruits soaked in tap water for 15min to serve as control, (T2) At pre-harvest, trees sprayed with tap water and harvested fruits soaked in calcium chloride solution at 1.5% for 15 min, (T3) At pre-harvest, trees sprayed with tap water and harvested fruits soaked in Ca Cl_2solution at 3.0% for 15 min, (T4) At pre-harvest, trees sprayed with vitamin B_{12} solution at 0.3mg.L^{-1}, (T5) At pre-harvest, trees sprayed with vitamin B_{12} solution at 0.3mg.L^{-1} and harvested fruits soaked in Ca Cl_2 solution at 1.5% for 15 min, (T6) At pre-harvest, trees sprayed with vitamin B_{12} solution at 0.3mg.L^{-1} and post-harvest fruits soaked in Ca Cl_2 solution at 3% for 15 min, (T7) At pre-harvest, trees sprayed with vitamin B_{12} solution at 0.6mg.L^{-1}, (T8) At pre-harvest, trees sprayed with vitamin B_{12} solution at 0.6mg.L^{-1} and post-harvest fruits soaked in Ca Cl_2solution at 1.5% for 15 min and (T9) At pre-harvest, trees sprayed with vitamin B_{12} solution at 0.6 mg.L^{-1} and post-harvest fruits soaked in Ca Cl_2 solution at 3.0% for 15 min. Pre-harvest spray treatments were at 10 days to harvest date with six trees each. They were immediately transported to the laboratory at Pomology department, Faculty of Agriculture, Mansoura University. Thoroughly washed with tap water and soap to remove impurities and microbial load on the fruit surfaces. The cleaned fruits were sorted for uniformity in size, maturity and freedom from defects.

Afterward, they refrigerated at 8±1°C and 80-85% relative humidity (RH) for cold storage course of 30 days. Fruits during cold storage period were subjected to measure three physical and six chemical characteristics at 6-day-intervals. Twelve fruits were randomly taken (represent each treatment) in three replicates to measure fruit decay and weight loss percentages. Two fruits in three replicates were randomly taken at 6-day-intervals to measure changes in the other tested fruit characteristics.

Physical and chemical characteristics measured during storage period

This part of experiment was dealt with 3 physical characteristics measured on the intact treated fruits, they were fruit firmness, it measured on two opposite sides at the equatorial region of unpeeled fruit using a hand penetrometer supplemented with probe of 8.0 mm diameter. Two fruits in three replications per treatment were tested. Each fruit was compressed 2% of its original diameter. Force in Newton (*N*) was recorded and expressed as multiplies by 100. (Reyes and Paull, 1995). Fruit weight loss percentage, twelve fruits in 3 replications per treatment was tested. The initial weight of each fruit was recorded at harvest date. The same fruits every 6 days of storage period were reweighted and the percentage of weight loss for each fruit was calculated in relation to its original weight. The obtained results were represented for each treatment as the average weight loss % of the tested fruits at the successive intervals till 30 days storage. Fruits decay incidence, was obtained from the number of fruits that showed signs of decay over the initial number of fruits. The percent decay was recorded at 6-day-intervals during cold storage period. The visible symptoms of fruits decay incidence were measured on 36 fruit (12 fruits in three replications) per each treatment. The current investigation also included determination of changes in six chemical characteristics in fruit juice and fresh ones during the same cold storage period. Ascorbic acid (Vitamin C) content in fruit juice was measured according to method described by Ranganna (1979) by the oxidation of ascorbic acid with 2, 6 dichlorophenolendophenol dye and the results were expressed as mg/100ml juice; acidity %in juice was determined by titrating the fruit juice, after diluting with distilled water, against 0.1 N sodium hydroxide (Na OH) solution in the presence of phenolphthalein as an indicator to the end point at pH 8.1 (Ranganna, 1979). Acidity content was expressed as citric acid percentage; Total soluble solids percentage (TSS %) was measured in fruit juice by the use of an Abbe hand refractometer (AOAC, 1985). The resulted values were represented as an average per treatment; Juice total soluble solids/acid ratio was calculated from the values recorder for TSS% and acidity% determinations. The obtained results were represented as an average ratio per treatment; Total soluble sugars percentages were determined according to method reported by Stewart (1974). Total phenols were extracted and determined in fresh fruit material according to the method outlined by Mazumadary and Majumder (2003). The amount of phenols actually presented in each sample was determined according to the standard curve prepared. The obtained results were recorded as an average value per treatment.

The experiment was laid out in a complete randomized design. The results were subjected to one-way analysis of variance (ANOVA) and the treatments were compared using the least significant difference (LSD) values at a significant level of $P<0.05$. All analyses were calculated using procedure of the Statistical Analysis System of SAS (1996).

RESULTS AND DISCUSSION

Guava (*Psidium guajava* L.) is an important fruit crop of the subtropical and tropical regions that present fast post-harvest ripening in a few days under ambient conditions. The main factors depreciating post-harvest quality in guava are fast loss of green color, excessive softening, high rot incidence and loss of turgidity. Therefore, the present work examined 9 treatments including pre-harvest sprays with tap water (control) or vitamin B_{12} solutions and post-harvest soaking fruits in calcium chloride solutions to study the behavior of certain physical and chemical characteristics of fruits during cold storage at $8±1^oC$ and 80-85% RH for 30 days.

1. Changes in fruit physical characteristics during cold storage period

Changes on three physical characteristics including fruit firmness, weight loss% and decay% are presented in Tables (1 to 3). Significant variations were observed in the behavior of these fruit parameters during cold storage period due to the tested treatments.

1.1. Behavior of fruit firmness during cold storage period

The periodical measurements clearly showed a decrease in fruit firmness values as the cold storage period advanced. The rates of such decrease were significantly differed among the tested treatments. Pre-harvest sprayed trees with vitamin B_{12} solution at $0.6mg.L^{-1}$ plus post-harvest the harvested fruits were soaked in Ca Cl_2 solution at 3.0% for 15 min "T9" was the best one to provide a consistent maximum retention of firmness during cold storage period. This super treatment was measured fruit firmness readings from 0 to 30^{th} storage day ranged from 15.76 to 9.60 and 16.86 to 10.49 *N* in 2007 and 2008 seasons, respectively. The next decreasing effect was resulted in fruits from trees pre-harvest sprayed with vitamin B_{12} at $0.6mg.L^{-1}$ solely"T7" or the same pre-harvest treatment plus post-harvest soaked the harvested fruits in Ca Cl_2 at 1.5% "T8". Such treatments respectively, tabulated values ranged from 15.86 to 7.90 and 16.82 to 9.26 *N* and from 15.85 to 8.35 and 16.74 to 9.32 in 2007 and 2008 seasons. On the other hand, Fruits of the control treatment "T1" recorded the highest decreasing rate with the range from 13.45 to 7.68 and 13.34 to 8.82 *N* in 2007 and 2008 respectively. Referring to trees under the rest treatments, they yielded fruits measured firmness readings during the same storage period and conditions of ranges between these two extremes (Table 1).

Comparing the above results clearly proved that the "T9"treatment was the best among the tested treatments to minimize the rate of decrease on fruit firmness till the end of storage period. Moreover, post-harvest soaking the harvested fruits in Ca Cl_2 solution at 3.0% had the main effect in that respect.

Basically, fruit firmness depends on many properties of the fruit tissue: water content, the nature of the cell wall and turgor are clearly important sources related to firmness. Also the breakdown of cell wall polysaccharides during shelf-life resulted in increasing activity some enzymes; polygalacturonases, cellulose and B-galactosidase (Lo'ay, 2005). Based on these, an explanation could be suggested for rapid decrease in firmness of fruits when they were immersed in B_{12} solution. However, fruit firmness declined much rapidly with control fruit than fruits were treated in B_{12} solution.

It could be illustrated that the hydrolysis process of cell wall polysaccharides enhanced more rapidly as affected by treating in B_{12} compared with treatment B_{12} and Ca Cl_2 together.

Table (1): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits firmness at 6-day-intervals during storage at 8±1°C and 80-85% RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	Fruit firmness(*N*)											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	13.45	13.34	10.77	11.63	9.75	10.31	8.60	9.24	7.91	9.21	7.68	8.82
TW + Ca Cl_2 at1.5%	T_2	13.51	13.24	12.64	11.15	11.37	10.62	9.20	10.54	8.36	10.07	7.85	9.23
TW + Ca Cl_2 at3.0%	T_3	13.45	13.31	11.34	11.58	10.64	11.29	9.49	10.64	8.44	10.45	8.38	9.30
VB_{12} at 0.3mg/l	T_4	10.91	13.50	10.49	10.26	8.86	9.39	8.46	9.28	8.39	8.65	8.35	8.55
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	10.93	13.46	9.92	11.34	9.73	10.56	9.17	10.10	8.71	9.34	8.55	8.73
VB_{12} at 0.3 mg/l + 3.0%Ca Cl_2	T_6	10.96	13.45	10.25	11.95	10.19	11.24	9.35	11.08	8.74	9.57	8.69	9.23
VB_{12} at 0.6mg/l	T_7	15.86	16.82	11.54	10.49	10.11	9.86	8.21	9.78	8.06	9.58	7.90	9.26
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	15.85	16.74	13.13	12.66	11.53	12.01	9.55	11.50	8.83	9.91	8.35	9.32
VB_{12} at 0.6 mg/l + 3.0%Ca Cl_2	T_9	15.76	16.86	14.67	13.34	13.50	12.65	10.71	11.77	10.57	11.38	9.60	10.49
L.S.D at 5%		0.55	0.19	0.87	1.27	0.72	0.82	0.37	0.50	0.66	0.54	0.60	0.48

1.2. Behavior of fruit weight loss% during cold storage period

The concerned results in Table (2) showed an obvious gradual increase in fruit weight loss% as the storage period advanced. The rates of such increase were differed from one treatment to another. The superiority in that respect significantly was to the treatment included pre-harvest sprayed trees with vitamin B_{12} solution at $0.3mg.L^{-1}$ and post-harvest the harvested fruits soaked in Ca Cl_2 solution at 3.0%for 15 min "T6" which tabulated values from 6 to 30^{th} storage day ranged from 1.63 to 4.33 and from 1.61 to 4.28% in 2007 and 2008 respectively. Otherwise, the control of "T1" treatment tabulated the highest periodical readings among the tested treatments during cold storage period. These results once more proved that the main effective factor on reducing weight loss% in cold stored guava fruits is related to post-harvest soaked fruits before storage in Ca Cl_2 solution at 3.0% for 15 min.

The above differences in behavior of fruit firmness and weight loss during cold storage could be due to the different water vapour permeability of the treated stored fruits. Differences in these fruit characteristics by Ca Cl_2 reducing effect are in complete agreement with the earlier report of Poovaiah *et al.,* (1988) who reported that in plant tissues calcium roles of particular interest, it increases cell membrane stability and cell wall strength. In the same line, Kirkly and Pilbeam, (1984) came to a similar fact indicating that membranes in tissues high reach in calcium have stronger cell walls and firmer than those severe from lack in adequate calcium. Fruit gradual increase on weight loss as the cold storage period advanced has also been reported earlier by Samaan *et al.,* (2001) who came to a similar behavior on fruits of 2 sweat orange cultivars post-harvest soaked in Ca Cl_2solutions.

Table (2): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits weight loss% at 6-day-intervals during storage at 8±1°C and 80-85% RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	Weight Loss%											
		Intervals in days											
		0*		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	818.44	820.25	2.44	2.40	4.83	4.82	7.32	7.25	7.82	7.73	8.67	8.41
TW + Ca Cl_2 at1.5%	T_2	751.43	720.71	2.74	2.64	4.36	4.30	6.05	5.97	6.99	6.98	7.78	7.74
TW + Ca Cl_2 at3.0%	T_3	775.21	765.12	2.44	2.41	3.52	3.44	4.61	4.47	5.16	5.04	5.74	5.70
VB_{12} at 0.3mg/l	T_4	820.89	840.13	2.35	2.24	3.89	3.85	5.49	5.47	6.37	6.36	7.18	7.09
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	779.90	760.42	1.25	1.06	3.01	2.99	4.94	4.92	5.66	5.60	6.35	6.25
VB_{12} at 0.3mg/l + 3.0%Ca Cl_2	T_6	889.24	840.39	1.63	1.61	2.53	2.42	3.36	3.22	3.78	3.70	4.33	4.28
VB_{12} at 0.6mg/l	T_7	803.01	794.10	2.90	2.84	4.00	3.95	5.20	5.06	6.09	6.04	6.40	6.36
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	748.56	720.31	1.51	1.50	2.65	2.62	3.78	3.74	4.34	4.24	5.07	5.03
VB_{12} at 0.6mg/l + 3.0%Ca Cl_2	T_9	822.61	803.01	0.53	0.51	2.13	1.76	3.39	3.01	4.11	3.78	4.26	4.62
L.S.D at 5%		63.19	31.25	0.09	0.09	0.34	0.13	0.29	0.09	0.27	0.35	0.42	0.23

0* Average fruit weight in gm at harvest date in both tested seasons.

1.3. Behavior of fruit decay% during cold storage period

The concerned results in Table (3) showed an obvious increase on fruit decay% as the cold storage period advanced in the two tested seasons. It was significantly the greatest in stored control fruits with decay% at the end of cold storage period of 37.60 and 29.57% in 2007 and 2008, respectively. Otherwise, among the other tested treatments stored fruits of T9, T8 and T7 treatments resulted in significantly the fewest decay percentages. They counted at the end of storage period fruit decay%, respectively 4.20, 5.60 and 9.77% in 2007. The corresponding percentages in 2008 season were 4.20, 5.60 and 9.73%.

As for the relationship between behaviors of the 3 fruit physical characteristics tested and post-harvest Ca Cl_2 treatments, Certain Calcium roles of particular interest must be cleared. Since these characteristics completely associated with fruit firmness. Calcium increases membrane stability and cell wall strength (Poovaiah and Glenn., 1985). As pointed out by Kirkly and Pilbeam, (1984) tissues high in Calcium have stronger cell walls are firmer and resist infection more readily. Otherwise, that lake of adequate Calcium leads to browning tissues. This positive effect of Ca clearly explains higher firmness for fruits of the treatments contained post-harvest soaked fruits in Ca Cl_2 solution (T8 & T9) at the end of storage period. Subsequently, they measured lower weight loss and decay percentages if compared with fruits of control and rest treatments.

Table (3): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits decay% at 6-day-intervals during storage at 8±1°C and 80-85 % RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	Decay%											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	0.00	0.00	0.00	0.00	1.40	1.40	4.20	2.80	11.17	8.40	37.60	29.57
TW + Ca Cl_2 at1.5%	T_2	0.00	0.00	0.00	0.00	0.00	0.00	2.80	1.40	5.60	4.20	22.23	16.90
TW + Ca Cl_2 at3.0%	T_3	0.00	0.00	0.00	0.00	0.00	0.00	1.40	1.40	2.80	2.80	11.20	11.10
VB_{12} at 0.3mg/l	T_4	0.00	0.00	0.00	0.00	0.00	0.00	1.40	2.93	5.50	4.20	18.73	16.77
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	0.00	0.00	0.00	0.00	0.00	0.00	2.80	4.20	5.60	5.60	16.67	12.90
VB_{12} at 0.3mg/l + 3.0%Ca Cl_2	T_6	0.00	0.00	0.00	0.00	0.00	0.00	1.40	1.40	4.20	4.10	13.87	12.47
VB_{12} at 0.6mg/l	T_7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.80	4.20	9.77	9.73
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.80	1.40	5.60	5.60
VB_{12} at 0.6mg/l + 3.0%Ca Cl_2	T_9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	1.40	4.20	4.20
L.S.D at 5%		---	---	---	---	---	---	**0.06**	**0.07**	**0.34**	**0.35**	**0.75**	**0.79**

2. Changes in fruit chemical characteristics during cold storage period

This part of the current study dealt with the effect of the tested treatments on behavior of six chemical characteristics in fruit juice and fresh fruits during the cold storage period. The periodical determinations of such characteristics are represented in Tables (4 to 9).

2.1. Behavior of fruit juice vitamin C during cold storage period (mg/100ml juice)

Results in Table (4) revealed an obvious decrease in fruit juice vitamin C as cold storage period advanced. This behavior was true in cold stored fruits of all the tested treatments with different rates. A comparison among these treatments indicated that the best ones to determine significantly the lowest decreasing rates were those of pre-harvest sprayed trees with vitamin B_{12} solution at 0.6mg.L^{-1} solely or followed by soaking the harvested fruits in Ca Cl_2 solution either at 1.5% or 0.3% (T7 to T9). The tabulated results for cold stored fruits of these treatments respectively, ranged from 86.07 to 62.32, 88.26 to 60.96 and from 89.46 to 71.04 mg/100ml juice in 2007 season along with from 87.09 to 62.38, 88.95 to 70.70 and from 90.78 to 75.81mg/100ml juice in 2008 season,. Otherwise, the highest rate of decrease was observed in stored fruits of control treatment “T1”. This inferior treatment ranged from 70.19 to 30.72 and from 70.82 to 30.49mg/100ml juice in 2007 and 2008 seasons, respectively.

4

The effective role of vitamin B_{12} in that respect might be explained as its activation on many carbohydrate metabolic processes that lead to an increase of glucose, fructose and sucrose during shelf-life period (Bubba, *et al.,* 2009; Asensi-Fabado and Munne-Bosch, 2010). So, Vitamin C was increase by increasing VB_{12} concentration, since the resulted monosaccharide sugar is an intermediate source in vitamin C pathway.

2.2. Behavior of fruit juice acidity% during cold storage

The results in Table (5) confirmed the superiority of pre-harvest sprayed trees with vitamin B_{12} solution at 0.6mg.L^{-1} solely"T7" or the same pre-harvest treatment plus soaking the harvested fruits in Ca Cl_2 solution either at 1.5% "T8" or 3.0% "T9" to produce fruits at harvest time contained significantly the lowest acidity% in juice. The determined values, respectively were 0.36, 0.34 and 0.41% in 2007 season as well as 0.35, 0.33 and 0.39% in 2008 one, respectively. As for behavior during cold storage period, the treatments including pre-harvest sprayed trees with vitamin B_{12} solution at 0.3mg.L^{-1} solely "T4" or associated with post-harvest soaking fruits in Ca Cl_2 solution at 1.5% "T5" or at 3.0% "T6" were the best ones to reduce juice acidity% till the end of cold storage period. They determined values from 0 to 30^{th} storage day for these treatments respectively were ranged from 0.79 to 0.11 ,0.85 to 0.11 and from 0.82 to 0.12 % in 2007 season as well as from 0.77 to 0.10, 0.83 to 0.12 and 0.80 to 0.12% in the other one. On the other hand, the lowest rates of decrease were resulted in stored fruits of the control treatment "T1" and those of pre-harvest sprayed trees with tap water plus post-harvest soaked the harvested fruits in Ca Cl_2 solution either at 1.5% "T2" or 3.0% "T3".

Table (5): Effect of pre-harvest sprayed trees with tap (TW) water or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits juice acidity % at 6-day-intervals during storage at 8±1°C and 80-85 % RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	Acidity %											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	0.90	0.86	0.75	0.72	0.62	0.59	0.38	0.37	0.29	0.28	0.17	0.15
TW + Ca Cl_2 at1.5%	T_2	0.92	0.89	0.74	0.72	0.45	0.44	0.29	0.27	0.23	0.23	0.16	0.14
TW + Ca Cl_2 at3.0%	T_3	0.78	0.77	0.68	0.66	0.46	0.45	0.25	0.24	0.17	0.16	0.14	0.13
VB_{12} at 0.3mg/l	T_4	0.79	0.77	0.72	0.71	0.65	0.63	0.32	0.31	0.22	0.21	0.11	0.10
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	0.85	0.83	0.64	0.70	0.54	0.55	0.45	0.44	0.16	0.16	0.11	0.12
VB_{12} at 0.3mg/l + 3.0%Ca Cl_2	T_6	0.82	0.80	0.72	0.71	0.65	0.63	0.30	0.29	0.19	0.19	0.12	0.12
VB_{12} at 0.6mg/l	T_7	0.36	0.35	0.26	0.24	0.25	0.21	0.20	0.18	0.16	0.15	0.14	0.12
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	0.34	0.33	0.32	0.31	0.25	0.19	0.18	0.16	0.16	0.15	0.14	0.13
VB_{12} at 0.6mg/l + 3.0%Ca Cl_2	T_9	0.41	0.39	0.33	0.32	0.25	0.22	0.17	0.16	0.15	0.13	0.13	0.12
L.S.D at 5%		0.08	0.07	0.06	0.07	0.05	0.05	0.03	0.05	0.02	0.04	0.03	0.02

Such inferior treatments tabulated at the same period, respectively the values from 0.90 to 0.17, 0.92 to 0.16 and 0.78 to 0.14% in 2007 season and from 0.86 to 015, 0.89 to 0.14 and from 0.77 to 0.13% in 2008 one. The rest treatments recorded values between these two extremes.

The above results are greatly cleared that the main factor to decrease juice acidity% at the end of cold storage period was sprayed trees with vitamin B_{12} at 0.3 mg.L^{-1}.

2.3. Behavior of fruit juice total soluble solids% during cold storage (TSS %)

During 30 cold storage days, TSS% in fruit juice under all the tested treatments was increased till different storage periods and then decreased to the end of storage period. Among the tested treatments those of pre-harvest sprayed trees with vitamin B_{12} at 0.3mg.L^{-1} plus post-harvest fruits soaked in Ca Cl_2 solution at 1.5 “T5”or 0.3% “T6” were the best ones to store the harvested fruits till the end of cold storage period having significantly the highest TSS% in juice. These treatments, respectively determined at 30th storage day the values 6.80 and 7.50% in 2007 season and 60.60 and 7.30% in 2008 season. Otherwise, the least values on the same day was resulted in fruit juice of the control treatment and those of T7 and T9 ones with the values, respectively 5.80, 5.10 and 5.30% in 2007 season and 5.70, 5.00 and 5.50% in 2008 one. The rest treatments produced fruits contained TSS% in juice at the same storage date between these two extremes (Table 6).

Table (6): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits TSS at 6-day -intervals during storage at 8±1°C and 80-85 % RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	TSS%											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	8.40	8.30	9.40	9.30	9.60	9.50	8.10	8.20	7.30	7.10	5.80	5.70
TW + Ca Cl_2 at1.5%	T_2	8.20	8.20	8.70	8.70	9.10	9.10	8.90	8.90	7.50	7.60	6.20	6.00
TW + Ca Cl_2 at3.0%	T_3	7.90	8.30	8.70	8.70	8.50	8.40	8.20	7.90	7.20	7.10	6.30	5.90
VB_{12} at 0.3mg/l	T_4	7.00	7.90	7.40	9.20	8.00	8.80	6.80	8.30	6.20	6.20	6.00	6.00
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	9.20	9.20	10.00	10.10	9.10	8.80	8.30	8.00	8.00	7.80	6.80	6.60
VB_{12} at 0.3mg/l + 3.0%Ca Cl_2	T_6	8.10	8.00	8.20	8.20	8.70	8.70	9.10	9.10	9.30	9.20	7.50	7.30
VB_{12} at 0.6mg/l	T_7	7.80	7.70	8.10	8.00	8.20	8.10	7.10	7.00	5.70	6.00	5.10	5.00
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	7.30	7.20	7.50	7.40	8.20	8.20	7.20	7.20	6.70	6.60	6.40	6.20
VB_{12} at 0.6mg/l + 3.0%Ca Cl_2	T_9	7.30	7.20	7.90	7.90	8.90	8.80	6.40	7.10	5.90	5.80	5.30	5.50
L.S.D at 5%		**0.41**	**0.28**	**0.53**	**0.76**	**0.09**	**0.08**	**0.25**	**0.16**	**0.34**	**0.11**	**0.36**	**0.20**

The above results proved that the treatments of pre-harvest vitamin B_{12} (at 0.3 $mg.L^{-1}$) spray plus soaking the harvested fruits before cold stored in Ca Cl_2 at 1.5% or 3.0% are considered the most effective ones to reduce decreasing rate in juice TSS% during storage period.

2.4. Changes in fruit juice TSS%/acid ratio

The concerned results in Table (7) indicated a gradual increase in juice TSS/acid ratio as storage period advanced. This behavior was the same during storage period for fruits of all treatments under study. The periodical calculations illustrated that the rates of increase were differed according to the applied treatment. Once more, the highest rates of increase were significantly resulted in fruits of T5 and T6 treatments. These super treatments, respectively calculated ratios from 0 to 30^{th} storage day ranged from 10.85 to 62.77 and 9.88 to 63.03 in 2007 and from 11.16 to 57.31 and 9.96 to 60.81 in 2008 one with insignificant difference between them. The least rate in that respect was in juice of the control fruits with the ratios from 9.37 to 34.70 and from 9.65 to 38.14 in 2007 and 2008, respectively. These results also pointed to pre-harvest vitamin B_{12} spray at 0.3$mg.L^{-1}$ plus soaking fruits before cold storage in Ca Cl_2 at 1.5% or 3.0% as the best treatments to maximize the rate of increase.

Table (7): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits juice TSS/acid ratio at 6-day-intervals during storage at 8±1°C and 80-85 % RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	TSS\acid ratio											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	9.37	9.65	12.63	13.02	15.54	16.14	21.32	22.17	25.19	25.84	34.70	38.14
TW + Ca Cl_2 at1.5%	T_2	8.97	9.25	11.86	12.04	20.16	20.61	31.17	32.57	32.61	33.48	39.60	43.94
TW + Ca Cl_2 at3.0%	T_3	10.13	10.78	12.85	13.30	18.28	18.74	33.29	33.09	41.57	44.17	43.98	45.13
VB_{12} at 0.3mg/l	T_4	8.92	10.24	10.33	13.03	12.31	13.97	21.26	26.90	28.18	29.52	55.15	58.18
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	10.85	11.16	15.63	14.36	16.81	16.09	18.52	18.37	49.79	49.83	62.77	57.31
VB_{12} at 0.3mg/l + 3.0%Ca Cl_2	T_6	9.88	9.96	11.38	11.50	13.44	13.79	30.40	31.64	49.12	49.32	63.03	60.81
VB_{12} at 0.6mg/l	T_7	21.67	22.09	31.28	33.90	33.26	38.57	34.76	38.89	35.42	40.00	37.36	41.67
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	21.49	21.63	23.39	24.15	32.60	43.16	39.30	44.31	42.60	45.78	47.12	47.69
VB_{12} at 0.6mg/l + 3.0%Ca Cl_2	T_9	18.00	18.43	23.98	24.63	35.53	40.84	37.53	44.58	39.56	44.87	40.51	45.83
L.S.D at 5%		1.75	2.46	1.18	1.52	2.31	2.40	1.63	1.17	1.42	2.37	0.97	3.14

2.5. Changes in fruit juice total soluble sugars%

Results in Table (8) showed an obvious gradual increase in juice total soluble sugars% of cold stored fruits as the storage period advanced. The rates of such increase were differed according to the tested treatment. During 30 storage days at 8±1^oC, the treatments of pre-harvest sprayed trees with vitamin B_{12} at 0.3 or 0.6mg.L^{-1} plus post-harvest soaked the harvested fruits in Ca Cl_2 solution either at 1.5% or 0.3% for 15 min (T5, T6, T8 and T9) were the most effective treatments to maximize the increasing rate if compared with the other ones. They determined the higher total soluble sugars percentages in fruit juice at the end of storage period. Such percentages respectively, were 8.47, 7.90, 8.25 and 8.24% in 2007season along with 8.45, 7.92, 8.28 and 8.22% in 2008 season. The superiority in that respect was to T5 treatment, since its stored fruits determined the highest total soluble sugars in fruit juice at the end of storage period (8.47 & 8.45%). Results in the same table also showed that the increasing rates for all the tested treatments significantly were higher than that of the control stored fruits during the same storage period and conditions.

These results mean that Ca Cl_2 either at 1.5% or 3.0% as post-harvest soaking solutions for 15 min were the main factor to increase total soluble sugars in juice of the cold stored fruits.

Table (8): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits total soluble sugars% at 6-day-intervals during storage at 8±1^oC and 80-85% RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	Total soluble Sugars%											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	5.21	5.24	5.40	5.78	5.78	6.76	6.35	6.38	6.85	6.88	7.01	7.05
TW + Ca Cl_2 at1.5%	T_2	5.22	5.23	5.51	5.54	6.04	6.06	6.95	6.99	7.12	7.09	7.27	7.25
TW + Ca Cl_2 at3.0%	T_3	5.24	5.26	5.91	5.93	5.93	5.96	6.79	6.77	6.97	6.94	7.14	7.12
VB_{12} at 0.3mg/l	T_4	5.54	5.52	5.63	5.68	6.20	6.23	7.03	7.04	7.24	7.28	7.31	7.35
VB_{12} at 0.3mg/l + 1.5%Ca Cl_2	T_5	5.50	5.49	6.04	6.02	7.02	7.04	8.04	8.06	8.32	8.35	8.47	8.45
VB_{12} at 0.3mg/l + 3.0%Ca Cl_2	T_6	5.51	5.54	6.31	6.37	6.57	6.58	7.52	7.53	7.73	7.76	7.90	7.92
VB_{12} at 0.6mg/l	T_7	5.68	5.67	5.76	5.78	6.40	6.44	7.43	7.45	7.62	7.64	7.74	7.75
VB_{12} at 0.6mg/l + 1.5%Ca Cl_2	T_8	5.65	5.67	6.20	6.16	6.85	6.86	7.85	7.82	8.06	8.09	8.25	8.28
VB_{12} at 0.6mg/l + 3.0%Ca Cl_2	T_9	5.65	5.67	6.53	6.52	6.72	6.73	7.73	7.75	7.92	7.95	8.24	8.22
L.S.D at 5%		**0.05**	**0.03**	**0.09**	**0.04**	**0.08**	**0.03**	**0.06**	**0.04**	**0.06**	**0.04**	**0.03**	**0.02**

2.6. Changes total phenols content in fresh fruits

The concerned results were recorded in Table (9). From these results, it was observed significant differences among the tested treatments along the storage period. The behavior of total phenols in fresh fruit of the tested treatments during cold storage period in general indicated a gradual decrease as storage period advanced.

9

The rates of such increase for all the tested treatments were lower than the control one "T1". Since they produced fruits at the end of storage period determined total phenols values significantly higher than that of the control fruits. The superiority in that respect was to the treatments of pre-harvest sprayed trees with vitamin B_{12} solution at 0.6 mg.L^{-1} plus post-harvest the harvested fruits soaked in Ca Cl_2 solution either at 1.5% "T8" or 3.0% "T9". They at the end of storage period respectively, determined total phenols values of 150.14 and 153.63 mg/100g FW in 2007 season along with 149.24 and 152.22 mg/100g FW in 2008 season.

The next lower rates were by "T6" and "T7"treatments, since they produced fruits contained at the same date respectively, values of 144.45 and 144.25 mg/100g FW in 2007 season along with 143.49 and 142.23 mg/100g FW in 2008 season, respectively. Otherwise, the fewest values (113.79 and 111.21 mg/100g FW) at the end of storage period were resulted in control fruits (T1) in both tested seasons. This means that both pre-harvest sprayed trees with vitamin B_{12} at 0.6 mg.L^{-1} plus post-harvest soaked fruits before cold storage in Ca Cl_2 at the two examined concentrations were the most effective factors to minimize the rate of total phenols decrease in stored fruits.

The need of post-harvest management of guava fruits in hi-tech way of handling, control of the ripening process and post-harvest changes of fruit characteristics are important to extend their period of availability in market without accelerate fruit quality loss and also to harness the export opportunities (Brown and Wills, 1983; Jacomino *et al.,* 2001 and Abu-Goukh, and Basheir,. 2003). Therefore the target of the present study was in this line. The obtained results revealed that factors affected the behavior of guava fruit characteristics during cold storage period were differed due to the measured characteristic. Post-harvest soaking the harvested fruits before storage in Ca Cl_2 solution at 3.0% for 15 min was the most effective factor to minimize the decreasing rates of fruit firmness, weight loss% and decay%. As for the behavior of chemical characteristics during cold storage period, pre-harvest sprayed trees 10 days to harvest date with vitamin B_{12} solution at 0.6 mg.L^{-1} and post-harvest soaked the harvested fruits in Ca Cl_2 solution either at 1.5% or 0.3% were among the tested treatments the best ones to maximize the rate of increase in juice vitamin C, total soluble sugars and phenols. Moreover, they kept fruits till the end of storage period contained the highest values of these characteristics if compared with the stored control fruits. The main effect in that increase was to Ca Cl_2 application as soaking solutions. These results are in line with Samaan *et al.,* (2001) working on sweet orange fruits post-harvest soaked in Ca Cl_2 solution at various concentrations. The obtained results showed a gradual increase on both fruit weight loss and decay percentages of the treated fruits as well as significant effect on the behavior of fruit chemical characteristics during storage was observed.

As for the behavior of acidity % in juice, the most effective treatment to determine the lowest acidity at the end of storage period was that of pre-harvest sprayed trees with vitamin B_{12} at 0.3mg.L^{-1}. On the other side, the same treatment plus soaking the harvested fruits in Ca Cl_2 solution at 1.5% or

0.3% were succeeded to store fruits till the end of storage period had the highest TSS% and TSS/acid ratio in juice.

The significant effects of Ca Cl_2 treatments in the present study could be explained as the vital roles of calcium in fruit tissues, but for the purpose of this discussion two of these roles are of particular interest. It increases membrane stability and cell wall strength (Poovaiah *et al.,* 1988). Kirkly and Pilbeam,(1984) also reported that tissues high in calcium have stronger cell walls , are firmer and resist infection more readily. Otherwise, lack of adequate calcium leads to lower respiration and ethylene production rates. Consequently, give better fruit quality and decrease the level of components responsible for fresh fruits (Van Reusburg and Engelbrecht, 1986). At the same time, calcium may act to chelate phenols and prevent their oxidation (Kirkly and Pilbeam, 1984).

CONCLUSIONS

The present study carried out during two successive seasons 2007 and 2008 on eighteen fruiting guava trees at 7-year-old grown in commercial orchard located at Damietta province, Damietta governorate, Egypt. The selected trees almost were uniform and apparently diseases free. They were subjected to receive nine treatments including three pre-harvest foliar sprays with tap water along with two vitamin B_{12} solutions at 0.3 and 0.6mg.L^{-1} ten days to harvest date. The other ones contained the later 2 treatments plus post-harvest the harvested fruits before stored at 8±^{o}C and 80-85% RH for 30 days were soaked in either tap water (control) or Ca Cl_2 solutions at 1.5 and 3.0% for 15 min. The harvested fruits after immediately transported to the laboratory of Pomology Department, Faculty of Agriculture, Mansoura University, thoroughly were cleaned and sorted for uniform in size, maturity and freedom from defects and divided into 2 lots contained 648 fruits each and contained the nine treatments tested. During cold storage period at 6-day-intervals, the stored fruits were subjected to measure three physical and six chemical characteristics to be used as criteria defining the best treatment to extend shelf life and keep acceptable guava fruit qualities during storage period.

Results of cold stored fruits recommended the treatment of pre-harvest sprayed guava trees with vitamin B_{12} solution at 0.6mg.L^{-1} ten days to harvest date plus post-harvest before storage soaked the harvested fruits in Ca Cl_2 solution at 3.0% for 15 min “T9” and stored at 8±1^{o}C and 80-85% RH as the best treatment to store guava fruits for 30 days contained at the end of cold storage period the highest firmness, vitamin C, total soluble sugars and total phenols. Otherwise, the lowest weight loss% and relatively lower acidity% in juice. The treatment of pre-harvest sprayed trees with vitamin B_{12} solution at 0.3mg.L^{-1} plus post-harvest soaked the harvested fruits in Ca Cl_2 solution either at 1.5% “T5” or at 3.0% “T6” were the superior among the tested treatments to tabulate the higher total soluble sugars, TSS% and TSS/acid ratio in juice of stored fruits at the end of cold storage period.

According to the forecited results of the present study, it could concluded that pre-harvest sprayed guava trees with vitamin B_{12} solution at 0.6mg.L^{-1} and post-harvest soaking the harvested fruits before cold storage in

Ca Cl_2 solution at any of the two tested concentrations each solely (T8 and T9) are the recommended ones to produce guava fruits with acceptable qualities during cold storage period tested the superiority was to "T9" treatment. Therefore, it is recommended to pre-and post-harvest technology in guava fruits. This recommendation lies in the fact that it has capability to iliminate avoidable post-harvest and storage losses along with maintain and enhance quality of stored fruits that make them ready marketable. Consequently this proper method is required to extend period of availability in market and also to harness the export opportunities to long distance marketing of guava fruits.

In view of economic point, this effective treatment in turn can maximize the net income of guava growers and producers throughout minimizing the costs associated with post-harvest losses during marketing or fruit storage and retail conditions.

REFERENCES

Abu-Goukh, A. A. and Basheir, H. A. (2003). Changes in pectic enzymes and cellulose activity during guava fruit ripening. J. Food Chemistry, 83(2): 213-218.

AOAC (1985). Official Methods of Analysis of Association of Official Agriculture Chemists. 4th ed. Washington D C, USA, pp.832.

Asensi-Fabado, M.A. and Munhe-Bosch, S. (2010). Vitamins in plants: Occurrence, biosynthesis and antioxidant function. Trends in plant Science, 15:582-592.

Brown, B. I. and Wills, R. B. H. (1983). Post-harvest changes in guava fruit of different maturity. Scientia Hort.,19:237-243.

Bubba, M.D; Qiordani, E.; Pippucci, L.; Cincihini, L.; Cincihinil, L. and Galvan, P. (2009). Changes in tannins, ascorbic acid and sugar content in astringent persimmons during on-tree growth and ripening in response to different postharvest treatments. Journal of Food Composition and Analysis, 22:668-677.

Cao, S. F.; Zheng, Y. H.; Wang, K.; Jin, P. and Rui, H. (2009). Methyl jasmonate reduces chilling injury and enhances antioxidant enzyme activity in post-harvest loquat fruit. Food Chem., 115:1458-1463.

Chin, H. F. and Young, H. S. (1980). Malaysian fruits in colour. Kuala lumpur: Tropical Press, Malaysia.

Chopda, C. A. and Barrett, D. M. (2001). Optimization of guava juice and powder production. J. Food Process. Press., 25: 411-417.

Conner, A. M.; Luby, J. J.; Hancock, J. M.; Berkheimer, S. and Hansen, E. J. (2002). Changes in fruit antioxidant activity among blueberry cultivars during cold temperature storage. J. Agric. Food Chem., 50: 893-898.

Elchel, J.; Gonzalez, J. C.; Hotze, M.; Matthews, R. G.; and Schroder, J. (1995). Vitamin-B_{12}- independent methionine synthase from a higher plant (*Catharanthus roseus*) Molecular characterization, regulation, heterologous expression, and enzyme properties. Eur. J. Biochem., 23:1053-1058.

Jacomino, A. P.; Minami, K.; Sarant´opoulos, C. I. G.; De, L.; Sigrist, J. M. M. and Kluge, R. A. (2001). Sensorial characteristics of ‘Kumagai‘ guavas submitted to passive modified atmosphere in plastic packages. J. Plastic Film Sheeting, Lancaster ,17: 1–17.

Kirkly, E. A. and Pilbeam, D. J. (1984). Calcium as a plant nutrition. plant cell and Environement, 7:397-405.

Kondo, S.; Tsuda, K.; Muto, N. and Ueda, J. (2002). Antioxidative activity of apple skin or flesh extracts associated with fruit development on selected apple cultivars. Scientia Hort., 96: 177-185.

Lee, S. K. and Kader, A. A. (2000). Pre-harvest and post-harvest factor, influencing vitamin C content of horticultural crops. Post-harvest Biology and Technology, 20: 207-220.

Lim, T. K. and Khoo K. C. (1990).Guava in malaysia:production, pests and diseases. Kuala lumpur :Tropical press, Malaysia.

Lo'ay, A.E. (2005). Chilling injury in mangoes. PhD Thesis. Wageningen University., ISBN: 90-8504-309-3:1-224.

Mazumadary, B. C. and Majumder, K. (2003). Methods on calcutta Univ., Trinagar, Delhi,124-125.

Mehaisen, S.M.A., (2005). Effect of spray with calcium and some post-harvest Treatments on fruit quality and storability of guava fruit. Annal . gric. Sci. Moshtohor, 43(1):327-339.

Mercado-Silva, E.; Bautista, P. B. and Velasco, M. D. L. A. G. (1998). Fruit development, harvest index and ripening changes of guavas produced in central Mexico. Postharvest Biol. Technol., 13:143–150.

Poovaiah, B. W.; Glenn, G. M. and Reddy, A. S. N. (1988).Calcium and fruit softening. Physiology and Biochemistry. Horticulture Reviews,10: 107-152.

Poovaiah, B. W. and Glenn, G. M. (1985). Cuticular permeability to calcium compounds in ‘Golden Delicious’ apple fruit. J. Amer. Soc. Hort. Sci., 110: 166–171.

Rajput, B. S.; Lekhe, R.; Sharma, G. ; Singh, I. (2008). Effect of pre and post harvest treatments on shelf life and quality of guava fruits. (*Psidium guajava* L.) cv. Gwalior-27. Asian Journal of Horticulture, 3(2):368-371.

Ranganna, S. (1979). Manual of Analysis of Fruit and Vegetable Products. 2nd Ed. Tata Mcgraw. Hill, publishing company Limited, New Delhi, pp. 634.

Reyes, M. U. and Paull, R. E. (1995). Effect of storage temperature and ethylene treatment on guava (*Psidium guajava* L.) fruit ripening. Post-harvest Biol. and Tech., 6: 357-365.

Samaan, L. G.; El-Boray, M. S. S.; Guirguis, F. G. and Helal, M. E. (2001).Post-harvest calcium treatments to improve keeping quality and marketing season of citrus fruits. J. Agric. Sci. Mansoura Univ., 20 (3): 1619-1631.

SAS (1996). Users Guide: Statistics, version 5 Ed. SAS Institute, Inc. Cary, NC, USA.

Stewart, E.A. (1974). Chemical Analysis of Ecological material. Black-Well Scientific Publication, Oxford.

Singh, R.; Chaturvedi, O.P.; Gaur, G.S. and Singh, G. (2007). Effect of pre-harvest spray of zinc, Calcium and boron on the storage behavior of guava (*Psidium guajava*. L.) fruits CV.Allahabad Safeda. ISHS Acta Horticulturae 735:International guava symposium 735-82.
Smirnoff, N. (1996). The function and metabolism of ascorbic acid in plants. Ann. Bot.,78:661 -669.
Smith, A.G.; Croft, M.T.; Moulin, M. and Webb, M.E. (2007). Plants need their vitamins to current. Opinion in Plant Biology, 10:266-275.
Van Reusburg, E. and Engelbrecht, A. H. P. (1986). Effect of Calcium salts on susceptility to browning of avocado fruit. Journal of Food Science, 51(4):1067-1070.
Wolfe, K.; Wu, X. and Liu, R. H. (2003). Antioxidant activity of apple peels. J. Agric. Food Chem., 51:609-614.
Zheng, W. and Wang, S. Y. (2003). Oxygen radical absorbing capacity of phenolics in blueberries, cranberries, chokeberries, and lingonberries. J. Agric. Food Chem., 51: 502-509.

معاملات لزيادة القدرة التخزينية و التسويقية لثمار الجوافة

لطيف جرجس سمعان، محمد عبدالرحيم عراقى، لؤى عبد اللطيف عرفت و تيسير عبدالحميد عبدالغفار سراج
قسم الفاكهة – كليةالزراعة - جامعةالمنصورة

أُجريت هذه الدراسة لموسمين متتاليين 2007-2008 على 18 شجرة جوافة مثمرة عمر سبع سنوات فى مزرعة تجارية خاصة تقع فى محافظة دمياط - مصروقد اختيرت الاشجار متماثلة فى الحجم تقريبا وخالية من الأمراض ظاهريا. تعرضت الاشجار المختارة لتسع معاملات منها ثلاث تم فيها رش الاشجار المختارة بماء الصنبور كمعاملة مقارنة و تم رش نصف الأشجار بمحلول فيتامين ب $_{12}$ عند تركيز 0.3 ملجم/لتر والنصف الاخر بنفس المحلول ولكن بتركيز 0.6ملجم/لتر وأجريت عمليات الرش قبل ميعاد جمع الثمار بعشرة أيام أما باقى المعاملات فقد اشتملت على المعاملتين الأخيرتين مع نقع الثمار المجموعة قبل التخزين على 8±1م° ونسبة مئوية للرطوبة 80-85% لمدة 30 يوم فى ماء صنبور (معاملة مقارنة) أو فى محلول كلوريد الكالسيوم عند تركيز 1.5 و 3.0% لمدة 15 دقيقة.

تعرضت الثمار خلال التخزين المبرد لفترات على 6 أيام لقياس التغيرات فى ثلاث صفات طبيعية (صلابة الثمار- النسبة المئوية للفقد فى الوزن ونسبة الثمار التالفة) وست صفات كيميائية (النسبة المئوية لمحتوى عصير الثمار من فيتامين ج والحموضة والمواد الصلبة الذائبة ونسبتها للحامض والسكريات الذائبة الكلية وكذلك محتوى الثمار الطازجة من الفينولات الكلية).

وقد أشارت النتائج المتحصل عليها الى:

1- أظهرت الثمار المخزنة تحت جميع المعاملات المختبرة خلال فترة التخزين البارد انخفاض تدريجى فى مستوى الصلابة مع تزايد تدريجى فى النسبة المئوية للفقد فى الوزن وعدد الثمار التالفة كلما امتدت فترة التخزين. وقد برهنت النتائج المتحصل عليها أن العامل الرئيسى فى هذا السلوك هو نقع الثمار قبل التخزين فى محلول كلوريد كالسيوم عند تركيز 3.0% لفترة 15 دقيقة بالمقارنة مع سلوك نفس الصفات الطبيعية على ثمار الكنترول وبقية المعاملات.

2- أوضحت نتائج سلوك الصفات الكيميائية خلال فترة التخزين البارد نقص تدريجى واضح فى محتوى عصير الثمار من فيتامين ج والنسبة المئوية للحموضة ومحتوى الثمار الطازجة من

الفينولات الكلية وعلى الجانب الأخر زيادة تدريجية فى محتوى عصير الثمار المخزنة من النسبة المئوية من المواد الصلبة الذائبة الى الحامض والسكريات الكلية الذائبة مع زيادة مرحلية فى النسبة المئوية للمواد الصلبة الذائبة . وقد بينت النتائج أيضا أن رش الأشجارقبل الجمع بمحلول فيتامين ب$_{12}$ يساعد على محافظة الثمار المخزنة على معظم الصفات الكيميائية فى عصير الثمار حتى نهاية فترة التخزين البارد المختبرة وكانت أفضل التركيزات هو 0.6ملجم/لتر.

3- أشارت النتائج أن المعاملة برش الأشجار قبل تاريخ الجمع بعشرة أيام بمحلول فيتامين ب $_{12}$ عند تركيز 0.6ملجم/لتر ثم نقع الثمار المقطوفة قبل التخزين البارد فى محلول كلوريد كالسيوم عند تركيز 3.0% هى الأفضل لتخزين الثمار لفترة 30 يوم وهى محتفظة عند اخر فترة التخزين بأعلى مستوى من الصلابة وأقل المعدلات من الثمار التالفة ونسبة الفقد فى الوزن. وسجلت أيضا ثمار هذه المعاملة أعلى محتوى العصير من فيتامين ج والسكريات الكلية الذائبة ومحتوى الثمار الطازجة من الفينولات الكلية.

4- أشارت النتائج المجدولة لبقية الصفات الكيميائية المختبرة الى المعاملة التى تم فيها رش الأشجار قبل الجمع بمحلول فيتامين ب $_{12}$ عند تركيز 0.3ملجم/لتر ونقع الثمار بعد الجمع فى محلول كلوريد الكالسيوم عند تركيز 1.5% أو 3.0% هماأفضل المعاملات فى احتفاظ الثمار بمستوى عالى من المواد الصلبة الذائبة ونسبتها للحامض عند نهاية فترة التخزين البارد .وعلى الجانب الأخر أقل نسبة مئوية للحموضة فى الثمار المخزنة تحت المعاملة بالرش قبل الجمع بمحلول فيتامين ب$_{12}$ عند تركيز 0.3ملجم/لتر.

5- أظهرت قيم متوسط القياسات المرحلية المحسوبة لكل معاملة توافق مع نتائج المعاملات المختبرة.

قام بتحكيم البحث

أ.د / محمد صلاح سيف البرعي	**كلية الزراعة – جامعة المنصورة**
أ.د / محمد محمد عطية	**كلية الزراعة – جامعة الإسكندرية**

J. Plant Production, Mansoura Univ., Vol. 3 (5): 857 - 876, 2012

Table (4): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits juice vitamin C at 6-day-intervals during storage at 8±1°C and 80-85% RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest Treatments	Symbol	Vitamin C content (mg/100ml juice)											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	70.19	70.82	74.47	75.43	51.77	52.47	42.66	42.42	35.02	35.56	30.72	30.49
TW + Ca Cl_2 at1.5%	T_2	70.91	72.20	78.34	79.72	62.24	68.39	48.36	47.75	39.50	40.90	31.32	30.88
TW + Ca Cl_2 at3.0%	T_3	70.57	71.34	84.53	83.99	72.04	72.02	49.50	49.97	41.35	41.99	34.75	35.20
VB_{12} at 0.3mg/l	T_4	73.16	72.80	93.79	93.79	78.75	78.50	55.71	55.84	39.46	40.39	36.52	37.85
VB_{12} at 0.3mg/l+ 1.5%Ca Cl_2	T_5	73.11	73.88	113.87	114.42	87.89	88.45	76.99	77.06	41.32	41.96	40.72	41.76
VB_{12} at 0.3mg/l+3.0%Ca Cl_2	T_6	74.75	74.74	122.37	123.08	97.76	97.89	87.23	86.13	71.42	71.53	42.66	42.16
VB_{12} at 0.6mg/l	T_7	86.07	87.09	143.83	144.19	118.65	118.83	70.42	70.62	66.20	66.90	62.32	62.38
VB_{12} at 0.6mg/l +1.5%Ca Cl_2	T_8	88.26	88.95	155.35	155.80	125.01	125.26	81.52	81.80	75.46	76.39	60.96	70.70
VB_{12} at 0.6mg/l+ 3.0%Ca Cl_2	T_9	89.46	90.78	166.99	167.04	141.23	142.03	117.98	118.91	96.52	96.19	71.04	75.81
L.S.D		**1.01**	**1.34**	**0.96**	**1.16**	**5.92**	**0.60**	**0.84**	**0.75**	**1.90**	**1.55**	**1.46**	**1.22**

Table (9): Effect of pre-harvest sprayed trees with tap water (TW) or vitamin B_{12} (VB_{12}) and post-harvest soaked the harvested fruits in calcium chloride solutions on behavior of guava fruits total phenols at 6-day-intervals during storage at 8±1°C and 80-85% RH for 30 days in 2007 and 2008 seasons.

Pre- and post-harvest treatments	Symbol	Total phenols (mg/100g FW)											
		Intervals in days											
		0		6		12		18		24		30	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
TW + TW	T_1	156.39	157.70	145.10	146.08	133.80	134.46	122.51	122.83	116.86	117.02	113.79	111.21
TW + Ca Cl_2 at1.5%	T_2	155.88	156.04	148.51	148.63	141.14	141.22	133.76	133.80	130.08	130.10	127.18	126.39
TW + Ca Cl_2 at3.0%	T_3	157.69	157.04	151.38	150.89	145.08	144.75	138.76	138.60	135.61	135.54	133.90	132.46
VB_{12} at 0.3 mg/l	T_4	165.66	164.39	158.12	157.17	150.58	149.95	143.03	142.72	139.27	139.11	136.06	135.49
VB_{12} at 0.3 mg/l + 1.5%Ca Cl_2	T_5	163.99	163.83	158.02	157.63	152.05	151.42	146.07	145.22	143.09	142.11	140.10	139.01
VB_{12} at 0.3 mg/l + 3.0%Ca Cl_2	T_6	164.90	165.66	159.79	160.12	154.67	154.58	149.57	149.03	147.01	146.26	144.45	143.49
VB_{12} at 0.6mg/l	T_7	177.07	175.80	168.86	167.41	160.66	159.02	152.45	150.63	148.35	146.43	144.25	142.23
VB_{12} at 0.6 mg/l + 1.5%Ca Cl_2	T_8	175.15	174.84	168.90	168.44	162.65	162.04	156.40	155.64	153.27	152.44	150.14	149.24
VB_{12} at 0.6 mg/l + 3.0%Ca Cl_2	T_9	174.27	174.90	170.40	169.23	163.95	163.56	158.79	157.89	156.21	155.06	153.63	152.22
L.S.D		**1.29**	**1.47**	**1.72**	**1.20**	**0.87**	**1.06**	**0.96**	**1.11**	**1.07**	**1.19**	**0.86**	**1.32**