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EFFECT OF SOME PACKAGING TREATMENTS ON BALADY LIME FRUITS UNDER COLD STORAGE CONDITIONS

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ABSTRACT

In 2010 and 2011 seasons, Balady lime fruits received some post-harvest packaging treatments (i.e., 1- packaging in plastic nets as control, 2- packaging in 0.08% perforated polyethylene bags, 3- packaging in 0.008% perforated polyethylene bags, 4- packaging in sealed foam plate by polyethylene stretch and 5- packaging in sealed carton boxes by polyethylene bags at rate of 190 ± 10 g fruits/ liter). The fruits of all treatments were stored at 12±1°C and 90 – 95% RH for four cold storage periods (30, 60, 90 and 105 days) followed by 5 days at 20°C and 60-70 % RH (similar to supermarket conditions).

The progressive advanced cold storage period caused significant increases in chilling injury index (CII), fruit decay (FD%), fresh weight loss (FWL %), peel color index (PCI), Juice %, juice TSS %, technological index (TI) and TSS / acidity ratio. While, juice Vit. C and Juice acidity % were depressed with increasing cold storage either during cold storage or shelf life periods.

All tested packaging treatments decreased CII, FD%, FWL %, pulp firmness (PF), juice TSS % and Juice acidity %. On the contrary, packaging treatments increased PCI of fruits during either cold storage or shelf life periods. Moreover, packaging treatments caused significant decreases in TI as compared with control during cold storage. In addition, packaging treatments did not significantly affect on Vit. C as will as TSS / acidity ratio during cold storage or shelf life period.

Generally, results the obtained make possible to recommend packaging Balady lime fruits in 0.08 % or 0.008 % perforated polyethylene bags then storage under cold conditions of 12±1°C and 90 – 95% RH for 90 days period. These combined treatments reduced exhibiting chilling injury and decay on fruits during cold storage and during the subsequent shelf period.

Key words: Packaging treatments, Balady lime fruits, cold storage conditions.

INTRODUCTION

Balady lime (*Citrus aurantifolia Swing*) is one of the most important citrus cultivars. In Egypt, lemon trees occupied 43688 *fed* produced 321281 tons. (Statistics of the Ministry of Agriculture, by Economic Affairs Sector 2009, Egypt).

Egyptian consumer prefers lime than lemon due to its high acidity and fruit size. There is a constant demand for Balady lime fruits throughout the year for local consumption and for exportation. Growers tried to apply some agricultural treatments such as fastening to prolong the lime marketing period. Such treatments resulted in harmful effects on trees. So, cold storage of harvested fruits was the suitable alternative way for prolonging occurrence lime fruits.

Cold storage represented the most promising method for increase storage life of Balady lime fruits to prolonging their marketing period and increasing their price (Kabeel, 1990). But, Lime fruits are subtropical origin and known as susceptible to chilling injury during cold storage (Paull, 1990 and Kader & Arpaia, 2000).

Storing packed fruits under cold conditions frequently reduced incidence chilling injury (CI) (Wardowsky *et al*., 1973 on lime and grapefruit); (Meir *et al*., 1998 on Fuerte avocado); (Pesis, *et al*., 2000 on mango); and (Porat *et al.,* 2004 on citrus fruits). On other hand, Yahia and Gonzalez, 1998 mentioned that packaging fruits under cold storage condition prolonged the storage life of avocados cv. Hass. Also, packaging fruits decreased fruit decay (Ramin and Khoshbakhat, 2008 on acid lime fruits); (Yaptertco *et al.,* 2010 on mango) and (Li Xianglin *et al*., 2011 on navel orange). While, Rygg and Wells (1962) reported that packing lemon fruits in plastic film may promote decay because the high levels of humidity and CO_2 within the sealed package.

Packaging fruits during cold storage decreased fresh weight loss(Ramin and Khoshbakhat 2008 on acid lime; Abdel Aziz *et al*., 2002 on Ponkan tangerine; Tefera *et al.*, 2007 on mango; Aryanpooya and Davarynejad 2010 on sour cherry; Sanches *et al.*, 2011 on loquat; Mohsen 2011 on peach and apricot and Mohammed and Wickham 2011 on balata fruits); and its improved color of strawberry (Aday *et al*., 2011). Packaging treatments retained fruit firmness higher than control (Aryanpooya and Davarynejad, 2010 on sour cherry; Aday, *et al*., 2011 on strawberry ; Mohsen 2011 on peach and apricot and Molder *et al*., 2011 on raspberry). But, Viskelis *et al.*, (2011) on apples clarify that firmness was decreased with the advance in cold storage period.

Packaging fruits did not significantly affect on fruit juice percentage (Cohen *et al.*,1990 on Murcott tangerine) and Obenland, *et al.*, 2008 on navel oranges). While, it decreased TSS (Aryanpooya and Davarynejad, 2010 on sour cherry; Li Xiang Lin *et al*., 2011 on navel orange and Mohsen, 2011 on peach and apricot). On the contrast, Ji Hua *et al.*, 2011 on Black Diamond plums) and Mohammed & Wickham 2011 on balata fruits) reported that TSS in fruit juice was increased with packaging treatments. Ramin and Khoshbakhat (2008) found that TSS of acid lime fruits did not significantly affected by packaging treatments.

Ascorbic acid content was decreased with packaging treatments (Li XiangLin *et al*., 2011 on navel orange and Viskelis *et al.,* 2011 on apples). But, it was retained with packaging treatments (Tefera *et al.,* 2007 on mango; Ramin and Khoshbakhat, 2008 on acid lime fruits and Mohammed and Wickham, 2011 on balata fruits).

Mohsen (2011) on peach and apricot and Li XiangLin *et al*. (2011) on navel orange found that packaging treatments decreased acidity percentage in fruit juice. While Obenland, *et al.* (2008) on Navel oranges; Ramin and Khoshbakhat (2008) on acid lime fruits and Sanches *et al.* (2011) on loquat noted that packaging treatments were insignificant effect on juice acidity. Tefera *et al.* (2007) on mango and Ji Hua *et al.* (2011) on Black Diamond plums recorded increases in acidity percentage by packaging applications. The SSC/TA ratio was increased during storage, it was mainly due to a decline in TA (Obenland, *et al*., 2008 on Navel oranges).

Therefore, the presented work aimed mainly to study the effect of packing types for extending period of cold storage and maintaining fruit quality of Balady lime fruits during storage and shelf life periods.

MATERIALS AND METHODS

This study was carried out during 2010 and 2011 seasons at the post-harvest laboratory of Horticulture Department, Faculty of Agriculture, Zagazig University, to evaluate the effectiveness of some packaging treatments prior to cold storage periods (30, 60, 90 and 105 days) for enhancing storability and the subsequent shelf life of Balady lime fruits(*Citrus aurantifolia Swing*).

Balady lime fruits were purchased from a private orchard at El-Adlia Blbies district, Sharkia Governorate, Egypt. Fruits at green ripe stages were harvested from similar trees aged 20 years old grafted on sour orange rootstock, grown in loamy soil at 5 x 5 meters apart. The fruits were picked using small clippers at1st January and packed in carton boxes and directly transferred to the laboratory. Then, fruits were washed, air dried and rechecked for any defects. Characteristics of the used fruits just prior to subjecting treatments are shown in Table A.

Table A: Characteristics of Balady lime fruits before cold storage treatments

The parameter	1st Season	2nd Season	The parameter	1st Season	2nd Season
Pulp firmness (kg/cm^2)	0.748	0.790	**Juice pH**	2.77	2.72
Juice %	30.0	29.8	**Juice acidity %**	8.97	9.01
Volume of juice / kg	315	310	**Juice vit. C (mg/ 100 cm^3 juice)**	65.7	61.2
Juice TSS %	10.7	10.5	**TSS/Acid. ratio**	1.19	1.15

The experimental design was factorial experiment between five packaging applications and four cold storage periods in completely randomized design, in three replicate, each replicate contained 500 grams fruits. The five packaging pre-storage applications were as follows:

1. Packaging in plastic nets (control).
2. Packaging in 0.08% perforated polyethylene bags (referred to as: perforated 0.08 PEB).
3. Packaging in 0.008% perforated polyethylene bags (referred to as: perforated 0.008 PEB).
4. Packaging in sealed foam plate by polyethylene stretch (referred to as: sealed foam plate PES).
5. Packaging in sealed carton boxes by polyethylene bags at rate of 190±10 g fruits/ liter (referred to as: sealed carton box PEB).

The packed fruits were subjected to four cold storage periods of 30, 60, 90 and 105 days. Storing was done at 12±1°C and 90-95% relative humidity. After cold storage fruits were hold for 5 days in an incubator at 20°C and 60-70 % RH (similar to supermarket conditions) to determine the effects on shelf life.

Data recorded:

Samples for each treatment were randomly taken after the above mentioned tested cold storage periods and the remained fruits of each treatment were used to detect shelf life determinations. However, evaluation of treatment effects after cold storage and shelf life was implicated fruit discarded attributes and fruit quality parameters as follows:

I. Discarded fruits attributes:

They were included:

1. **Chilling injury index (CII):** Chilling injury symptoms were included pitting, staining and necrotic areas on fruit peel (Sanchez-Ballesta *et al*., 2003). It was assessed according to the following index: 0= without decay; 2= spot decay; 4= 25-50% decay; 8= >50 % decay.

2. **Fruit decay percentage (FD %)**: It was determined as percentage of rotted fruits from the total fruits of each replicate.

*II. **Other fruit quality parameters:***

They were included fruit physical and chemical properties of peel, pulp and juice of fruits as follows:

1. **Fruit weight losses percentage (FWL %) :** Fruits were weighed just before and after cold storage treatments and the 5 days of shelf life, and then FWL % was calculated.
2. **Peel color index (PCI):** Fruits color after each treatment was determined according to the following index: 1 = 100 % green; 2 = < 25 % yellow; 3 = 26-50 % yellow and 4 = > 50 % yellow.
3. **Pulp firmness:** Five fruits for each replicate were used to determine pulp firmness as kg / cm^2. A push pull Dynamometer (Model FD 101) was used in this concern.
4. **Juice percentage:** The extracted juice of random fruit samples of each replicate was weighted and juice content was expressed as percent of fruit weight (w/w).
5. **Juice total soluble solids percentage (TSS %):** It was determined using a hand refractometer.
6. **Ascorbic acid (Vit.C) content in juice:** It was determined as milligrams ascorbic acid / 100 ml fruit juice using the procedures which described by Lucass (1944).
7. **Juice total acidity (%)**: It was determined by titration against 0.1N sodium hydroxide in presence of phenolphthalein dye according to the method described by A.O.A.C. (1980).
8. **Technological index (TI) :** It was determined using the following equation: TI = (TSS % X juice %) /100. Technological index variable is an important indicator for citrus industry. Higher values of TI mean better quality for juice manufacture (Chitarra and Chitarra, 1990).
9. **TSS / acid ratio**.

Statistical analysis:

Collected data were subjected to statistical analysis according to the methods described by Snedecor and Cochran (1989). Mean separation was done using Duncan multiple range test at 5 % level (Duncan, 1958). Because of severe damage of stored fruits under the long tested storage period of 105 days regarding chilling injury index and decay percentage which don't permit to assess the other fruit quality parameters, the application of 105 days storage period was canceled during the statistical analysis respecting the majority of fruit quality parameters.

RESULTS AND DISCUSSION

1. Discarded fruits attributes [chilling injury index (CII) and fruit decay percentage (FD %)]:

1.1. During cold storage:

Data in Table 1 it is clear that CII and FD % were increased with advancing cold storage period. Lowermost values of CII and FD % were recorded after 30 days, and then they were steadily increased with the advance in storage period to reach the uppermost values after 105 days.

Packed fruits in plastic nets (control treatment) consistently showed the highest CII (4.81 and 4.67 in the two seasons, respectively); while all packaging treatments greatly decreased CII in both seasons; the least values in this respect were noticed in fruits packed in perforated polyethylene bags. Also, FD % values were significantly decreased in packaging treatments compared with to control treatment; with an exception of the sealed carton box PEB treatment, since it recorded the highest FD % values in both seasons. The least FD % was recorded in fruits packed in perforated polyethylene bags treatments (Table 1).

The interaction between cold storage period and packaging treatments was significant in the two seasons respecting CII and FD % (Table 1). The least values came from the 30 days cold storage interacted with any tested packaging treatments. Prolonging the interacted cold storage period increased CII and FD % under the same treatment. While, the highest values of CII and FD % came from the interaction between 105 days storage period with the sealed carton box PEB treatment (7.57 & 7.80 and 100 & 100% in the first and second seasons, respectively).

1.2. During shelf life

Data in Table 2 indicate that shelf life fruits revealed similar trend as that mentioned for cold period, packaging treatments and interaction between cold storage period and packaging treatments with CII and FD % in the two seasons.

The reduction in CII with packaging treatments was in agreement with results of Wardowsky *et al.*, (1973) on limes and grapefruit; Pesis, *et al.*, (2000) on mango; Meir *et al.*, (1998) on Fuerte avocado and Porat *et al.,* (2004) on citrus fruits. The reduction in FD% with packaging treatments are agree with the results obtained by (Ramin and Khoshbakhat, 2008) on acid lime fruits; Yaptertco *et al.*, (2010) on mango and Li XiangLin *et al.*, (2011) on navel orange, but Rygg and Wells (1962) reported that plastic film may promote decay of fruits lemons because of high levels of humidity and CO_2 within the sealed package.

2- **Other fruit quality attributes:**

2.1. ***Fruit weight loss percentage (FWL %); peel color index (PCI) and pulp firmness (PF):***

2.1.1. During cold storage:

It is clear that FWL % and PCI was gradually increased with advancing cold storage period in both studied seasons (Table 3). The FWL % and PCI were 4.77 & 5.88% and 2.48 & 2.54 after 30 days cold storage in both seasons, respectively, while they reached 13.9 & 14.2% and 3.82 & 3.89 in the two seasons respectively, after 90 days cold storage. But, pulp firmness was significantly affected only in the second season.

All packaging treatments caused significant decreases in FWL % and PF as compared with control in both seasons. The lowest values of FWL % came from perforated 0.008 PEB treatment (2.46 and 2.40 % in both seasons) without significant with perforated 0.08 PEB treatment and the lowest values of PF came from sealed foam plate PES treatment without significant with all packaging treatments in the second season. Moreover, all packaging treatments caused significant increases in PCI as compared with plastic nets treatment (control) in both seasons (Table 3).

The interaction between cold storage period and packaging treatments had significant effects in the two seasons with FWL % and PF but in the second season only with PCI. The least values of FWL % came after 30 days cold storage interacted with perforated 0.008 PEB treatment (0.40 and 0.73 % in the first and second seasons). While, the highest values came from the interaction between 60 or 90 days cold storage periods with the control treatment (38.0 & 36.3 and 41.3 & 40.3 % in the first and second seasons, respectively). The highest values of PF came from 90 days cold storage interacted with control, while the least ones came from 90 days cold storage X sealed foam plate PES treatment in the first season and after 60 days cold storage X perforated 0.08 PEB treatment in the second one (Table 3).

2.1.2. During shelf life

Data in Table 4 show that FWL%; PCI and PF during shelf life were significantly affected by cold storage period. As such, after 90 days of cold storage the fruits showed higher FWL% & PCI and lowest firmness after 5 days shelf life as compared with other storage periods treatments.

The perforated PE treatments obviously depressed FWL %, however, sealed foam plate PES and sealed carton box PEB treatments increased FWL % in both seasons. Control fruits revealed the lowest PCI (3.13 and 3.07 in the two seasons), while the packaging treatments caused significant increases in PCI during both seasons. The least values for PF

came from the control and sealed carton box PEB treatments compared with other treatments in the two seasons (Table 4).

The interaction between cold storage period and packaging treatments was significant with FWL %; PCI and PF after 5 days shelf life in the two seasons (Table 4). The lowest values of FWL% came after 60 days cold storage interacted with perforated 0.08% PEB treatment in the first season while in the second one after 90 days cold storage interacted with perforated 0.008% PEB treatment. The highest values of FWL % came from 90 days cold storage with sealed carton box PEB treatment in the two seasons. The least PCI after 5 days shelf life in the two seasons resulted after 30 days cold storage with all packaging treatments, while; the highest values were recorded after 90 days cold storage by all packaging treatments. The highest PF during shelf life came after 60 days cold storage with sealed foam plate PES treatment and the least values after 90 days cold storage by sealed PE treatment in the two tested seasons.

The present work revealed that FWL % were increased as cold storage period increased, this was in line with results of Ramin and Khoshbakhat (2008) on acid lime; Abdel Aziz *et al*., (2002) on Ponkan tangerine; Ding *et al.*, (2002) on loquat; Tefera *et al.*, (2007) on mango; Aryanpooya and Davarynejad (2010) on sour cherry; Sanches *et al.*, (2011) on loquat; Mohsen (2011) on peach and apricot and Mohammed and Wickham (2011) on balata fruits. Water loss can be one of the main causes of deterioration, since it not only results in indirect quantitative losses, but also causes losses in appearance (due to wilting and shriveling) and nutritional quality. Packaging does not directly influence the rate of water loss, but the need for a gas tight environment for packaging during storage and transport often results in significantly higher relative humidity around the commodity and consequently reduces water loss compared to air storage (Kader, 1986).

Also, data showed that all packaging treatments recorded highest PCI compared with the control treatment and it was increased with the advance in cold storage period. These results was agreed with Aday, *et al*., (2011) on strawberry.

The reduction in PF with packaging treatments was contradicted with Aryanpooya and Davarynejad (2010) on sour cherry; Aday *et al*., (2011) on strawberry ; Mohsen (2011) on peach and apricot ; Molder, *et al*. (2011) on raspberry and Viskelis *et al.* (2011). The higher water loss in control fruits compared with packaging treatments may be causes an increase in hardiness of fruit peel and pulp during storage.

2.2. Juice %, juice TSS % and juice Vit. C:

2.2.1. During cold storage

From Table 5, it is clear that Juice % and juice TSS % were increased with the advance of cold storage period to reach uppermost values after 90 days. But, Vit. C was gradually decreased with advancing cold storage period in both studied seasons.

Also, data of the same Table 5 show that packaging treatments had significant effects on juice % during cold storage in both seasons. The highest values of juice % were recorded in fruits packed in plastic nets treatment (34.5 and 36.9 % in the two seasons, respectively); while the least values were recorded in fruits packed in sealed carton box PEB (26.8 and 27.6 % in the two seasons, respectively). The other tested treatments ranged between them. In addition, TSS was significantly affected by the tested packaging treatments as compared with the control. Packed fruits in the two tested perforated PEB recorded the least values in this respect without significant differences between them, while, control treatment recorded the TSS percentages (10.0 and 9.96 % in the first and second seasons, respectively). Ascorbic acid was significantly affected by packaging treatments in the second season only.

The interaction between cold storage period and packaging treatments recorded significant effects with juice % and juice TSS % during cold storage in the two seasons. While, Vit.C was significantly affected in the second season only (Table 5). The lowest juice % was recorded in fruits packed in perforated (0.08 % or 0.008%) PEB after 30 days storage period or in fruits packed in sealed carton box PEB after 60 days. This was true during the two seasons. While, the highest juice % was resulted under the effect of interaction treatment of 90 days cold period X sealed foam plate PES (40.3 %) in the first season and under 90 days X plastic nets treatment in the second season (41.0 %). At the same time, the highest values of juice TSS % came after 90 days X control packing treatment (10.6 and 10.8 % in the two seasons, respectively); while the least values were recorded after 60 days X perforated 0.08 % PEB treatment in the first season (8.90 %) and after 90 days with control (8.97 %) in the second one.

2.2.2. During shelf life

Juice % was increased and Vit.C was decreased during shelf life as the cold storage period was increased up to the longest period in the two seasons. But, juice TSS % was significant in the second season only Table (6).

Packaging treatments recorded increments in Juice % and depressed juice TSS % during shelf life compared to the control. Packaging treatments had significant effects on Vit.C and the highest values came from sealed foam plate PES during both seasons (Table 6).

Also, the same Table 6 showed that the interaction between cold storage period and packaging treatments recorded significant effects with juice %; juice TSS % and Vit.C after 5 days shelf life in the two seasons. The least values of juice %; juice TSS % and Vit.C resulted after 30 days cold storage with control packing treatment (28.4 and 29.9 %); after 90 days cold storage with perforated 0.08% PEB treatment (8.83 and 8.80 %) and after 90 days cold storage with perforated 0.08% PEB treatment (31.8 mg/100 ml juice in the first season and with control treatment 32.5 mg/100 ml juice in the second one).

All packaging treatments depressed juice % during cold storage compared to the control. However, Cohen *et al.,* (1990) on Murcott tangerine and Obenland *et al.,* (2008) on Navel oranges recorded that juice % was insignificantly affected by the tested packaging treatments. The decrease in juice % as affected by packaging treatments and during storage period could be due to water loss from fruit peel or pulp.

The reduction in juice TSS % with packaging was in agreement with results of Aryanpooya and Davarynejad (2010) on sour cherry; Li XiangLin *et al*., (2011) on navel orange and Mohsen (2011) on peach and apricot. On the contrast, Ji Hua *et al.,* (2011) on Black Diamond plums and Mohammed and Wickham (2011) on balata fruits reported that TSS in juice fruits was increased with packaging treatments. While, it was insignificantly affected by the tested packaging treatments as compared with control in acid lime fruits (Ramin and Khoshbakhat, 2008); in Navel oranges (Obenland, *et al.*, 2008) and in apples (Viskelis *et al.*, 2011). The gradual increase in the percentage of TSS with the increase of storage period could be due to the degradation of complex insoluble compounds, like starch, to simple soluble compounds, like sugars, which are the major TSS components. Also, the increase in TSS percentage might be due to water loss by transpiration during storage period (Hussein *et al*. 1998).

Ascorbic acid content was decreased with the advance of storage period, while, it was insignificantly affected by the tested packaging treatments as compared with control. Li XiangLin *et al*., (2011) on navel orange and Viskelis *et al.,* (2011) on apples reported that ascorbic acid content was decreased with packaging treatments. But, it retained with packaging treatments (Tefera *et al.,* 2007 on mango; Ramin and Khoshbakhat, 2008 on acid lime fruits and Mohammed and Wickham, 2011 on balata fruits). The loss in ascorbic acid content during storage might be attributed to the rapid conversion of L-ascorbic acid into dihydro-ascorbic acid in the presence of L-ascorbic acid oxidase (Hussien *et al.* 1998).

2.3. Juice acidity %, technological index (TI) and TSS / acidity ratio

2.3.1. During cold storage

It is clear that juice acidity % was gradually and significantly decreased with advancing storage period in the two seasons (Table 7). The least values were recorded after 90 days (6.62 and 6.73%) in the two seasons. On the contrary, TI and TSS / acidity ratio were increased with the advance in cold storage period and reached its maximum values (3.53 & 3.75 and 1.45 & 1.50) after 90 days of cold storage in the two seasons, respectively.

All packaging treatments (Table 7) caused significant decreases in juice acidity % and TI as compared with control in both seasons. The least values came from sealed carton box PEB treatment (6.47 & 6.61 % and 2.51 & 2.68) in the two seasons. The highest values represented TSS/ acidity ratio were recorded in fruits packed in sealed carton box PEB during the two tested season.

The interaction between cold storage period and packaging treatments (Table 7) had significant effects with juice acidity %, TI and TSS / acidity ratio during cold storage in the two seasons. The highest values of juice acidity % were found in fruits packed in plastic nets and stored for 90 days (7.80 % in first season) and after 60 days (7.83 % in second season), while the lowest values came after 90 days cold storage (5.63 and 6.33 % in both seasons) with sealed carton box PEB treatment. The highest values of TI resulted after 90 days with plastic nets (4.07 and 4.44 in both seasons) and the lowest values resulted after 30 days with perforated 0.008% PEB treatment (2.38 in the first season) and with sealed carton box PEB treatment (2.53 in the second season). Moreover, the highest values of TSS / acidity ratio occurred after 90 days with sealed carton box PEB treatment (1.68 and 1.63 in both seasons) but, the least values obtained after 30 days with plastic nets treatment (1.19 and 1.17 in both seasons).

2.3.2. During shelf life

Data in Table 8 show significant effects regarding effect of storage period on juice acidity %, TI and TSS / acidity ratio during shelf life in both seasons and revealed similar trend as that mentioned above for cold storage.

Packaging in plastic nets recorded the highest juice acidity % without significant differences with the two sealed treatments during shelf life and the lowest values came from the two perforated PEB treatments without significant differences between them in both seasons. Control fruits revealed the lowest TI (3.28 and 3.17 in the two seasons), while the highest values came from sealed foam plate PES treatment (4.31 and 4.51) in both seasons. But, the effect of packaging treatments on TSS / acidity ratio during shelf life was significant in second season only (Table 8).

The interaction between cold storage period and packaging treatments in Table 8, had significant effects with juice acidity % and TSS / acidity ratio in the first season only and TI in the second season only during shelf life.

Packaging treatments significantly lowered total acidity compared with control. Also, acidity was gradually decreased with the advance in storage period. These results were in line with those reported by Mohsen (2011) on peach and apricot and Li XiangLin *et al*., (2011) on navel orange. From results it is clear that TSS / acidity ratio values were increased with increasing cold storage period. In this regard, Obenland, *et al.*, (2008) on Navel oranges reported that SSC/ TA ratio was significantly increased during storage; this was mainly due to a decline in total acidity.

Conclusively, results of the present work, generally, make possible to recommend storage Balady lime fruits at 12^{o}C up to 90 days after packaging by perforated (0.08 or 0.008 %) polyethylene bags to decreasing chilling injury index and fruit decay percentage during cold storage and shelf life periods.

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تأثير بعض معاملات التعبئة على ثمار الليمون البلدي تحت ظروف التخزين البارد

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تلقت ثمار اليلمون البلدى أثناء موسمي ٢٠١٠ ، ٢٠١١ بعض معاملات التعبئه بعد الحصاد (١- التعبئة في شباك بلاستيك للمقارنة ، ٢- التعبئة في أكياس بولي إثيلين مثقب بنسبة ٠.٠٨ % ، ٣- التعبئة في أكياس بولي إثيلين مثقب بنسبة ٠.٠٠٨ % ، ٤- التعبئة في أطباق "فوم" محكمة الغلق بواسطة بولي إثيلين استريتش ، ٥ - التعبئة في علب كرتون محكمة الغلق بواسطة أكياس من البولي إثيلين بمعدل ١٩٠± ١٠ جم ثمار/ لتر) ثم تخزين كل الثمار المعامله على ١٢±١ °م ورطوبة نسبية ٩٠- ٩٥ % لأربع فترات تخزين بارد (٣٠ ،٦٠ ،٩٠ ،١٠٥ يوم) تلاها خمس أيام على درجة حرارة ٢٠°م ، ٦٠- ٧٠% رطوبة نسبية (وسط مشابهه لظروف السوبر ماركت).

أدت زيادة فترة التخزين البارد إلى زياده معنوية في كل من التقدير الرقمي لأضرار البرودة ، نسبة الثمار التالفة ، نسبة الفقد في الوزن الطازج ، التقدير الرقمي للون القشرة ، النسبة المئوية للعصير ، النسبة المئوية للمواد الصلبة الذائبة ، الدليل التكنولوجي ونسبه المواد الصلبة الذائبة للحموضة ، بينما انخفض كل من محتوى الثمار من فيتامين ج ونسبة الحموضة بزيادة فترة التخزين البارد إما بعد فترات التخزين البارد أو فترة العرض.

أدت كل معاملات التعبئة المختبرة إلى خفض كل من التقدير الرقمي لأضرار البرودة ، نسبة الثمار التالفة ، نسبة الفقد في الوزن ، وصلابة اللب ، ونسبه المواد الصلبة الذائبة و نسبة الحموضة في العصير ، بينما أدت إلى زيادة التقدير الرقمي للون القشرة أثناء التخزين البارد أو أثناء فترة العرض ، أيضا أدت معاملات التعبئة إلى خفض الدليل التكنولوجي مقارنة بمعاملة المقارنة بعد فترة التخزين البارد ، ولم تؤثر على ومحتوى الثمار من فيتامين ج ونسبه المواد الصلبة الذائبة للحموضة بعد فترة التخزين البارد وفترة العرض.

من النتائج المتحصل عليها يمكن التوصية بتخزين ثمار الليمون البلدي في أكياس مصنوعة من البولي إيثلين المثقب بنسبة ٠.٠٨% أو ٠.٠٠٨ % تحت ظروف التخزين البارد على درجة حرارة ١٢ °م ، ٩٠- ٩٥% رطوبة نسبية لمدة ٩٠ يوم ، حيث قللت هذه المعاملات من ظهور أضرار البرودة و تلف الثمار أثناء التخزين البارد و فترة العرض.