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Effect of Storage Temperatures and Postharvest Calcium Salts Treatments on Storability of Jujube Fruits (*Zizphus mauritiana* Lam.cv.Tufahi).

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Abstract

Jujube fruits cv.Tufahi were collected from commercial orchard in Abu-Alkhaseb region south of Basrah during the growing season 2010 for the purpose of improving the storability of fruits. Selected fruits were treated with calcium salts(calcium chloride 4% w/v, calcium nitrate 4% w/v, calcium chloride 4% + calcium nitrate 4% w/v and control), packed with perforated and non perforated polyethylene bags (1 kg, 12 holes per bag) in addition to control (without polyethylene bags),and stored at 0 º C and 5 ºC. Results of this study show that decay percentage decreased in fruits treated with calcium chloride 4% + calcium nitrate 4% w/v and stored without polyethylene bags for both temperatures, however the highest percentage of decay were at 5 º C. In additions, some of fungi were identified which were the main reason for decay of fruits (*Penicillium italicum, Penicillium degitatum, Alternaria alternate, Rhizopus stolonifer, Fusarium monoliforme, Cladosporium oxysporum, Sclerotinia sclerotiorum*). Fruits treated with calcium chloride 4% + calcium nitrate 4% w/v and packed with non perforated polyethylene bags showed significantly lower percentage of weight loss than those treated with other treatments. Total soluble solids and total sugars decreased in fruits treated with calcium chloride 4% + calcium nitrate 4% w/v and packed with non perforated polyethylene bags, whereas the highest percentage of total soluble solids and total sugars were in control fruits. Total titratable acidity and ascorbic acid reduced in all stored fruits at the end of storage. However, the highest changes in these parameters were found in fruits stored at 5 º C as compared with 0 º C.

Keywords: jujube fruits, storability, calcium chloride, calcium nitrate, fungi, decay, polyethylene bags

Introduction

Jujube trees belongs to genus: Zizphus.and to family Rhamnaceae which considered one of the largest plant families in the world containing about 58 genus and 900 species distributing in tropical and subtropical regions of the world. (Cronquist, 1981, Williams *et al.*,2006).

Jujube fruits have a high nutrient value due to their constituents such as vitamin C , carotene, carbohydrates, protein, and some mineral elements particularly phosphorus and iron, One of the problems facing these fruits is the short shelf life that may be due to internal fruit disorders which are directly related to low fruit calcium levels . Al-sareh (1988) showed that jujube fruits cvs. Zautoni and bambawi could be stored for 4 , 5 weeks at 4 º C and for 4,6 days at room storage temperature (in arrangement).

It has been known that a wide range of internal fruit and vegetable disorders are of a physiological nature and these were directly associated with low calcium levels which have been positively linked with disorders such as bitter pit in apples (Schumacher et.al, 1977); blossom-end rot in tomatoes, internal browning in Brussels sprouts.

Calcium has a number of vital roles in plant tissues, but for the purpose of this discussion two of these roles are of particular interest: first, Calcium increases membrane stability, second, Calcium increases cell wall strength (Poovaiah et al., 1988). As pointed out by Conway *et al*.(1992) postharvest treating of apple fruits with calcium chloride decreased the decay of fruits particularly caused by fungi infections. Al-hmedawi(2002) refers that soaking of apples with the solution of calcium chloride reduced physiological disorders in fruits during three months of storage at 5 º C. similar results were found in pear fruits by Al-mefergi (2006) .

Tufahi cultivar is one of the most important cultivars of jujube in Basrah region south of Iraq. It has a good global fruit volume and greenish-yellow color at maturation (Al-Rubaai,1998).Regarding to the limited studies used postharvest calcium salts especially calcium nitrate which used for the first time to elongation the shelf life of Tufahi fruits according to the available literatures, the aim of this study is to improve storability of Tufahi fruits by treating them with postharvest calcium salts and packing in polyethylene bags.

Materials and Methods

Jujube fruits cv.Tufahi were collected from a commercial orchard in Abu-Alkhaseb region south of

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Basrah during the growing season 2010. Trees were subjected to the same agricultural practices and grown in clay soil. Selected fruits were similar in size and appearance. Others which were small and deteriorated were not selected. Fruits treated after harvesting with calcium salts (calcium chloride 4% w/v, calcium nitrate 4% w/v, calcium chloride 4% + calcium nitrate 4% w/v and control (distilled water only)), packed in perforated and non perforated polyethylene bags (1 kg, 12 holes per bag) in addition to control (without polyethylene bags) and stored at 0 º C and 5 ºC for five weeks. The following parameters were determined at the end of storage:-

1. Decay percentage:-It was measured according to the following formula:-

$$\text{Decay percentage} = \frac{\text{Number of deteriorated fruits per bag}}{\text{Number of total fruits per bag}} \times 100$$

2. Weight loss (%): was measured via the changes in fresh weight of fruits during storage

3. Total soluble solids (T.S.S.) of fruit pulps were measured by hand refractometer (°Brix) and the results were corrected to 20 º C.
4. Total sugars (%) of fruits were determined according to Lane and Eynon method outlined in A.O.A.C. (1990)
5. Total titratable acidity (%) and ascorbic acid (mg/100gm fresh weight) were determined according to the method outlined in A.O.A.C. (1990).
6. Fungi were identified in the laboratory of plant production department.

Data obtained by determining some chemical characteristics of postharvest Tufahi fruits were 17.5% total soluble solids, 12.3% total sugars, 0.75% total titratable acidity and 151.22 mg/100g ascorbic acid. Complete Randomized Design was used with three replicates . The results were analyzed by the analysis of variance and mean values were compared using the Revised Least Significant Difference Test at 0.05 probability level. (Al-Rawi and Khalf Allah,1980).

Results and Discussion

Data presented in table (1) showed the changes in decay percentage, loss in weight (%) of jujube fruits at the end of storage at 0 º C and 5 ºC. Results referred to decrease in decay percentage of treated fruits with calcium salts as compared to that of control treatment. The data in this table also showed that calcium chloride 4% + calcium nitrate 4% w/v treatment of stored fruits without polyethylene bags significantly decrease decay percentage as compared to other treatments. The highest decay percentage (5.07%) was produced by control treatment in packed fruits with non perforated polyethylene bags.

Calcium confers a number of benefits. The first of these is an increment in fruit firmness that leads to delay ripening and increased the shelf life of fruits. This is in agreement with the findings of Taain.(2006) who concluded that calcium confers increased firmness, reduced decay of fruits, delayed ripening and extended storage life of Tufahi jujube fruits. Another benefit arising from calcium applications is an improvement in internal quality. It is clear that Tufahi fruits cracking reduced in fruits treated with calcium salts than those of untreated. Kirkby and Pilbeam (1984) mentioned that tissues high in calcium have stronger cell walls, are firmer and resist infection more readily. Some of fungi were identified which were the main reason for decay of fruits (*Penicillium italicum, Penicillium degitatum, Alternaria alternate, Rhizopus stolonifer, Fusarium monoliforme, Cladosporium oxysporum, Sclerotinia sclerotiorum*). Results also indicated that the loss of weight percentage was significantly reduced in fruits treated with calcium chloride 4% + calcium nitrate 4% w/v and packed with non perforated polyethylene bags. Loss in weight percentage significantly increased in stored fruits (particularly without polyethylene bags) at 5 ºC than those at 0 ºC. this may be due to an increment of evaporation of water in fruits stored at 5 ºC. moreover, as the fruits advanced toward senescence there was a reduction in water content with the values of control treatment being significantly higher than those treated with calcium salts. The loss of water content in the fruits associated with the processes of ripening and senescence occurred rapidly at high temperature (Baile and Yang ,1981).

Table (2) summarized the effect of calcium salts treatments, packages and storage temperatures on some chemical characteristics of Tufahi fruits during storage. Fruits treated with calcium chloride 4% + calcium nitrate 4% w/v % and packed with non perforated polyethylene bags showed a significant reduction in total soluble solids(%) and total sugars(%) when compared to control and other treatments. The highest percentages of total soluble solids and total sugars were found in control (14.78%, 9.34%) in arrangement. No significant differences were found between both calcium treatments (calcium chloride 4% w/v , calcium nitrate 4% w/v) in this respect. In general, treatment with calcium salts led to reduced a total soluble solids and total sugars which may be due to the role of calcium in delaying ripening processes taking place in fruits related to the reduction of ethylene production (Ferguson *et al.*, 1995). In avocados, some of researchers have shown that postharvest calcium applications, which give higher fruit calcium levels, result in lower respiration and ethylene production rates. These treatments also give better fruit quality and longer ripening times (Wills and

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Tirmazi, 1982; Eaks, 1985).

There were significant differences between storage temperatures as regards the average of total soluble solids and total sugars values in which stored fruits at 0 ºC were higher in their content of total soluble solids and total sugars than those stored at 5 ºC at the end of storage periods. These findings are in accordance with those previously reported by Taain(2005)for Barhi date cultivar ,Hamzah (2010) for Hillawi and Sayer date cultivars.

Total titratable acidity was reduced in all treated and untreated fruits during storage. However, treatments with calcium salts differed significantly in their effect on the percentage of total acidity of Tufahi fruits, with 4% w/v calcium chloride + 4% w/v calcium nitrate treatment giving the highest value of total acidity when compared to the values of 4% w/v calcium chloride treatment, 4% w/v calcium nitrate treatment and the control. Results also showed That fruits treated with calcium chloride 4% + calcium nitrate 4% w/v and packed with non perforated polyethylene bags have the highest value of total acidity, while the lowest value of total acidity were found in control fruits stored without polyethylene bags. These results were in line with those obtained by Taresh (2009) for Barhi and Hilalli date cultivars. The patterns of changes in average ascorbic acid (mg/100gm fresh weight) values of fruits treated with calcium salts during storage were almost similar to that in the control. These results came in agreement with those reported by Taain (2006). As mentioned previously in total acidity, There was also reduction in the values of ascorbic acid in all stored fruits after five weeks in both temperatures. However, the highest changes in these parameters were found in fruits stored at 5 º C as compared with 0 º C.

In conclusion, postharvest application of calcium salts (particularly calcium chloride 4% + calcium nitrate 4% w/v) improved storability of treated fruits by reducing decay and loss weight percentages It would seem, therefore, possible to use calcium salts as postharvest treatment to save qualitative values of Tufahi jujube fruits. It was also well noted that storage of fruits at 0 º C was better than 5 º C in retaining the internal quality of fruits.

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Table 1. Effect of storage temperatures, calcium salts and packages on Decay (%) and weight loss (%) of Tufahi jujube fruits

Storage temperatures	Treatments	packages	Decay (%)	Weight loss (%)
0 º C	control	Without polyethylene bags	2.21	1.72
		Non perforated polyethylene bags	4.61	1.36
		perforated polyethylene bags	4.11	1.47
	calcium chloride 4%	Without polyethylene bags	2.11	1.62
		Non perforated polyethylene bags	4.55	1.26
		perforated polyethylene bags	4.03	1.35
	calcium nitrate 4%	Without polyethylene bags	2.15	1.69
		Non perforated polyethylene bags	4.48	1.21
		perforated polyethylene bags	3.89	1.35
	calcium chloride 4% + calcium nitrate 4%	Without polyethylene bags	1.13	1.42
		Non perforated polyethylene bags	3.22	1.11
		perforated polyethylene bags	2.95	1.25
5 º C	control	Without polyethylene bags	2.65	3.1
		Non perforated polyethylene bags	5.53	2.55
		perforated polyethylene bags	4.86	2.79
	calcium chloride 4%	Without polyethylene bags	2.46	2.87
		Non perforated polyethylene bags	5.33	2.43
		perforated polyethylene bags	4.7	2.61
	calcium nitrate 4%	Without polyethylene bags	2.41	2.75
		Non perforated polyethylene bags	5.33	2.5
		perforated polyethylene bags	4.62	2.61
	calcium chloride 4% + calcium nitrate 4%	Without polyethylene bags	1.85	2.52
		Non perforated polyethylene bags	3.66	1.02
		perforated polyethylene bags	3.21	2.1

Decay percentage(%)
R.L.S.D. $P < 0.05 = 0.11$ (between calcium treatments)
R.L.S.D.$P < 0.05 = 0.52$ (between storage temperatures)
R.L.S.D. $P < 0.05 = 0.51$ (between packages)
R.L.S.D. $P < 0.05 = 0.45$ (interaction between calcium treatments and storage temperatures)
R.L.S.D. $P < 0.05 = 0.78$ (interaction between calcium treatments and packages)
R.L.S.D. $P < 0.05 = 0.41$(interaction between packages and storage temperatures)
R.L.S.D. $P < 0.05 = 1.77$ (interaction between calcium treatments , packages and storage temperatures)
Weight loss (%)
R.L.S.D. $P < 0.05 = 0.41$ (between calcium treatments)
R.L.S.D. $P < 0.05 = 1.02$ (between storage temperatures)
R.L.S.D. $P < 0.05 = 0.25$ (between packages)
R.L.S.D. $P < 0.05 = 0.15$ (interaction between calcium treatments and storage temperatures)
R.L.S.D. $P < 0.05 = 0.58$ (interaction between calcium treatments and packages)
R.L.S.D. $P < 0.05 = 0.20$ (interaction between packages and storage temperatures)
R.L.S.D. $P < 0.05 = 1.05$ (interaction between calcium treatments , packages and storage temperatures)

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Table 2. Effect of storage temperatures, calcium salts and packages on some chemical characteristics of Tufahi jujube fruits

Storage temper-atures	Treatme-nts	Packages	Total soluble solids (%)	total sugars (%)	Total titratable acidity (%)	ascorbic acid (mg/100g)
0 º C	control	Without polyethylene bags	15.1	9.33	0.3	133
		Non perforated polyethylene bags	14.6	9.11	0.35	130.12
		perforated polyethylene bags	14.2	8.69	0.32	130.07
	calcium chloride 4%	Without polyethylene bags	13.3	7.83	0.36	133
		Non perforated polyethylene bags	13	7.37	0.48	133
		perforated polyethylene bags	12.7	7.11	0.45	130.22
	calcium nitrate 4%	Without polyethylene bags	13.3	7.77	0.36	132
		Non perforated polyethylene bags	13.1	7.55	0.52	130.17
		perforated polyethylene bags	12.6	7.02	0.45	130
	calcium chloride 4% + calcium nitrate 4%	Without polyethylene bags	11.2	5.63	0.38	132
		Non perforated polyethylene bags	10.2	4.72	0.42	133
		perforated polyethylene bags	10.7	5.26	0.40	130.17
5 º C	control	Without polyethylene bags	15.6	10.33	0.24	125.06
		Non perforated polyethylene bags	14.2	8.87	0.28	125.06
		perforated polyethylene bags	15	9.73	0.26	126
	calcium chloride 4%	Without polyethylene bags	15.2	10.01	0.3	123.07
		Non perforated polyethylene bags	14.5	9.26	0.35	126.2
		perforated polyethylene bags	15	9.69	0.32	126
	calcium nitrate 4%	Without polyethylene bags	15.2	9.76	0.30	125.06
		Non perforated polyethylene bags	14.6	9.92	0.35	126.07
		perforated polyethylene bags	15	10.03	0.32	126.12
	calcium chloride 4% + calcium nitrate 4%	Without polyethylene bags	12	8.66	0.28	123.15
		Non perforated polyethylene bags	10.7	7.15	0.36	123.15
		perforated polyethylene bags	11	7.57	0.30	125.27

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Total soluble solids (%)
R.L.S.D. $P < 0.05 = 0.79$ (between calcium treatments)
R.L.S.D. $P< 0.05 = 1.11$ (between storage temperatures)
R.L.S.D. $P< 0.05 = 0.15$ (between packages)
R.L.S.D. $P< 0.05 = 1.65$ (interaction between calcium treatments and storage temperatures)
R.L.S.D. $P< 0.05 = 0.38$ (interaction between calcium treatments and packages)
R.L.S.D. $P< 0.05 = 1.22$ (interaction between packages and storage temperatures)
R.L.S.D. $P< 0.05 = 2.36$ (interaction between calcium treatments , packages and storage temperatures)

Total sugars (%)
R.L.S.D. $P < 0.05 = 0.65$ (between calcium treatments)
R.L.S.D. $P< 0.05 = 1.51$ (between storage temperatures)
R.L.S.D. $P< 0.05 = 0.12$ (between packages)
R.L.S.D. $P< 0.05 = 0.59$ (interaction between calcium treatments and storage temperatures)
R.L.S.D. $P< 0.05 = 0.45$ (interaction between calcium treatments and packages)
R.L.S.D. $P< 0.05 = 1.61$ (interaction between packages and storage temperatures)
R.L.S.D. $P< 0.05 = 2.25$ (interaction between calcium treatments , packages and storage temperatures)
Total titratable acidity(%)
R.L.S.D. $P < 0.05 = 0.01$ (between calcium treatments)
R.L.S.D. $P< 0.05 = 0.06$ (between storage temperatures)
R.L.S.D. $P< 0.05 = 0.02$ (between packages)
R.L.S.D. $P< 0.05 = 0.05$ (interaction between calcium treatments and storage temperatures)
R..L.S.D. $P< 0.05 = 0.03$ (interaction between calcium treatments and packages)
R..L.S.D. $P< 0.05 = 0.06$ (interaction between packages and storage temperatures)
R.L.S.D. $P< 0.05 = 0.07$ (interaction between calcium treatments , packages and torage temperatures)
ascorbic acid (mg/100gm)
R.L.S.D. $P < 0.05$ = N.S (between calcium treatments)
R.L.S.D .$P< 0.05 = 5.5$ (between storage temperatures)
R.L.S.D. $P<0.05$ = N.S (between packages)
R..L.S.D. $P< 0.05 = 4.11$ (interaction between calcium treatments and storage emperatures)
R..L.S.D. $P< 0.05$ = N.S (interaction between calcium treatments and packag)
R..L.S.D. $P< 0.05 = 4.66$ (interaction between packages and storage temperatres)
R..L.S.D. $P< 0.05$ = N.S (interaction between calcium treatments , packages and storage

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تأثير درجة حرارة الخزن والمعاملة بأملاح الكالسيوم بعد الجني في القابلية الخزنية لثمارالسدر صنف التفاحي

(*Zizphus mauritiana* Lam.cv.Tufahi).

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الملخص

جمعت ثمار السدر صنف التفاحي من أحد البساتين التجارية في أبي الخصيب ، جنوب البصرة خلال موسم النمو 2010 بهدف تحسين القابلية الخزنية للثمار. أختيرت الثمار المتماثلة بالحجم واستبعدت الثمار المتضررة والصغيرة الحجم وعوملت بأملاح الكالسيوم (كلوريد الكالسيوم 4% و/ح ، نترات الكالسيوم 4% و/ح ، كلوريد الكالسيوم 4%+نترات الكالسيوم4%و/ح) اضافة الى معاملة المقارنة. ثم عبئت الثمار بأكياس البولي أثيلين غير المثقبة والمثقبة (1كغم، 12ثقب في الكيس)اضافة الى ثمار المقارنة (بدون استخدام أكياس البولي أثيلين)وخزنت على درجتي حرارة 0°م و5°م. أوضحت نتائج الدراسة أن نسبة التلف انخفضت معنويا في الثمار المعاملة بكلوريد الكالسيوم 4%+نترلات الكالسيوم 4% وغير المعبأة بأكياس البولي أثيلين ولكلتا الدرجتين الحراريتين. ومع ذلك فأن أعلى نسبة للتلف كانت بدرجة حرارة 5°م . وقد تم تشخيص عدد من الفطريات والتي كانت السبب الرئيسي وراء تلف الثمار (*Penicillium italicum, Penicillium degitatum, Alternaria alternate, Rhizopus stolonife, Fusarium monoliforme, Cladosporium oxysporum, Sclerotinia sclerotiorum*).

الثمار المعاملة بكلوريد الكالسيوم 4%+نترات الكالسيوم4% والمعبأة بأكياس البولي أثيلين غير المثقبة أظهرت انخفاض معنوي في نقصان الوزن. المواد الصلبة الذائبة والسكريات الكلية انخفضت في الثمار المعاملة بكلوريد الكالسيوم 4%+نترات الكالسيوم4% والمعبأة بأكياس البولي أثيلين غير المثقبة. غير ان أعلى نسبة للمواد الصلبة الذائبة الكلية والسكريات الكلية كانت في ثمار معاملة المقارنة.الحموضة الكلية وفيتامين C انخفضا في جميع الثمار المخزونة نهاية فترة الخزن وكان الانخفاض أكبر في الثمار المخزونة بدرجة 5°م مقارنة مع درجة 0°م.

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