

Effects of pre-storage dipping in calcium chloride and salicylic acid on the quality attributes of stored Khalal Barhi dates

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Abstract: Barhi is a high-quality date cultivar, typically harvested and consumed fresh at the Khalal maturity stage when the fruits are crispy and sweet with bright yellow color. The shelf-life of the Khalal stage (2-3 weeks) is very short for effective marketing. This study aimed at investigating the role of calcium chloride (CaCl₂) and salicylic acid (SA) as pre-storage treatments in preserving the color and texture of the fruit during both cold and controlled atmosphere (CA) storage systems. Fresh-harvested Barhi fruits at the Khalal stage were treated with CaCl₂ (2%) or SA (2.0 mM), and then stored in cold and CA systems. The weight loss and decay percentages in the treated samples decreased, whereas the total soluble solids of the treated samples increased compared with those of the untreated ones. The best treatment in limiting changes in the color and texture of the fruits was CaCl₂ treatment during CA storage.

Keywords: Barhi dates, calcium chloride, salicylic acid, color texture, controlled atmosphere storage

DOI: 10.25165/ijabe.20201303.4983

Citation: Atia A, Abdelkarim D, Younis M, Alhamdan A. Effects of pre-storage dipping in calcium chloride and salicylic acid on the quality attributes of stored Khalal Barhi dates. Int J Agric & Biol Eng, 2020; 13(3): 206–212.

1 Introduction

Date palm (*Phoenix dactylifera* L.) is an ancient fruit tree that yields berry fruits (dates), which constitute a primary food staple in the Middle East and North Africa region, where hundreds of date cultivars are grown and play a significant role in the economy, history, and culture of the people^[1]. Dates are non-climacteric fruit, with shallow metabolic activity. They are considered nutritious and provide quick energy intake because of their high inverted sugar content along with minerals, vitamins, phenols, flavonoids, anthocyanin, carotenoids, and fiber with low-fat content^[2-6]. The development of date fruit goes through five maturity/ripening stages: Hababouk, Kimri, Khalal (Bisr), Rutab, and Tamer. Usually, dates are harvested and marketed at the last three stages of maturity and can be consumed soft, semi-dry or dry, depending on the cultivar features, climatic conditions, and market demand^[7]. High quality date cultivars such as Barhi are attracting a rising demand in international markets. The Barhi cultivar is a popular cultivar widely grown in the Middle East. Barhi dates are usually harvested and consumed fresh at the Khalal stage of maturity when the fruits are crispy and sweet with a bright yellow

skin color. After harvesting, Barhi dates rapidly converts to the Rutab stage (in few days) where their tissues become softer, and their skin color turns to brown; at this stage, however, their consumer demand and market price decrease significantly^[7]. Therefore, slowing fruit ripening after harvesting to extend their shelf life is crucial for marketing the harvested Barhi dates.

Postharvest storage life of fruits and vegetables can be extended by cold storage as well as controlled atmosphere (CA) storage. Furthermore, postharvest treatments, such as dipping in aqueous CaCl₂ or SA, could be used to improve the storability of several types of horticultural produce^[8-10]. Dipping in CaCl₂ has been used for regulating fruit ripening, retaining fruit color and texture, and extending the postharvest life for figs, blackberries, raspberries, and strawberries^[9,11]. Similarly, salicylic acid (SA) a natural and safe phenolic plant compound, is used mainly in regulating postharvest losses of horticultural produce^[12]. Several studies have addressed the effects of SA on bananas, kiwifruit, navel oranges, and plums^[13-16].

It appears that data on the effects of postharvest treatments on the storability of fresh Barhi dates has been limited. The objective of this current work was to investigate the influence of postharvest dipping in aqueous CaCl₂ and SA on the weight loss, fruit decay, total soluble solids (TSS), color, and texture of Barhi dates at the Khalal stage during cold and CA storage.

2 Materials and methods

2.1 Materials

Fresh Khalal Barhi dates were obtained from a commercial farm in Riyadh, Saudi Arabia and transferred on the same day to King Saud University (CDIT/Food Processing Laboratories). The dates were sorted for uniformity in maturity and color and cleaned to remove dust and adherent dirt. The data on the initial physical properties (mass, volume, length, diameter, moisture content, TSS%, and color values (*L*, *a*, and *b*) of the dates were measured and presented in Table 1.

Received date: 2019-02-17 **Accepted date:** 2020-03-26

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Table 1 Basic physical properties of fresh Barhi fruits at Khalal stage of maturity

Property	Mass/g	Volume /cm ³	Length /mm	Diameter /mm	Moisture content (w.b)/%	TSS/%	Color values		
							<i>L</i>	<i>a</i>	<i>b</i>
Mean	9.23±0.42	10.08±0.65	28.70±0.14	23.19±0.25	66.28±1.02	26.31±0.27	52.48±0.91	2.04±0.40	30.40±0.54
n	50	50	50	50	50	50	50	50	50

2.2 Treatments

Barhi dates were randomly divided into three collections for the following treatments in triplicate: the first set was immersed for 5 min in an aqueous solution of CaCl₂ (2%), the second in SA (2 mM), and the third set was immersed in distilled water (control). Concentrations of (CaCl₂) and (SA) were chosen from preliminary experiments. Dipping of the samples was done using perforated plastic containers (approximately 10 kg each). Subsequently, the samples were left to dry at room temperature (25 °C) then placed into cold storage (0 °C, 80% ±5% RH) and CA storage (0 °C, 5% O₂, 5% CO₂, 80% ±5% RH).

2.3 Measurements

The various quality characteristics of the Barhi dates were taken at the beginning for the fresh samples and then measured at 10 d intervals during cold storage and 20 d intervals during CA storage. The experiments were performed when the stored samples reach room temperature (25°C). The tests were terminated after 40 d and 120 d for cold storage and CA storage, respectively, when the samples became 50% Rutab or decayed.

The weight of the samples was determined by a digital balance (Model 204, Mettler, Toledo, Switzerland). The fruit weight loss was calculated based on the initial weight and expressed in percent. The total soluble solids (TSS)% of the samples was measured at room temperature (25°C) using a digital refractometer (Abbe 5 Refractometer, Bellingham & Stanley (BS), Jena, Germany) and expressed as a percentage^[17]. Samples were frequently checked for decay (Rutab or deteriorated) during the testing. The percent decay was calculated according to:

$$\text{Fruit decay (\%)} = \left[\frac{\text{Number of decayed fruits}}{\text{Total number of fruits}} \right] \times 100$$

A Hunter Lab-scan XE spectrophotometer was used to measure Hunter basic color parameters (*L*, *a*, and *b*) for the samples, where parameter (*L*) indicates brightness/darkness, parameter (*a*) indicates redness/greenness, and parameter (*b*) indicates yellowness/blueness. The average values of the basic color parameters (*L**, *a**, and *b**) were used to calculate the derivative color parameters (total color difference (ΔE), Chroma, and hue angle (*H*)) as defined by Maskan^[18].

A texture analyzer (TA-HDi, Model HD3128, Stable Micro Systems, Surrey, England) was used to measure the textural profile analysis (TPA) parameters of the Barhi dates. The samples were compressed to a depth of 5 mm with a cylinder at a velocity of 1.5 mm/s. The resultant force-time deformation of two curves were used in determining the hardness, elasticity, and chewiness of the Barhi dates^[19].

2.3 Sensorial attributes

The sensory evaluation of the quality of the fresh and stored Barhi dates was conducted using the 9-point hedonic scale^[20]. The evaluated sensory qualities were: texture, taste, color, and overall acceptability. The responses were converted to numbers ranging from 1 for “dislike extremely” to 9 for “like extremely” with 5 for “neither like nor dislike”.

2.4 Data analysis

The obtained data were examined by the analysis of variance

(ANOVA) test using SPSS software package (IBM SPSS version 22). The statistical differences between the calculated means were established by the least significant difference (LSD) multi-comparison test and significant differences were reported at *p*-value ≤0.05.

3 Results and discussion

3.1 Fruit weight loss

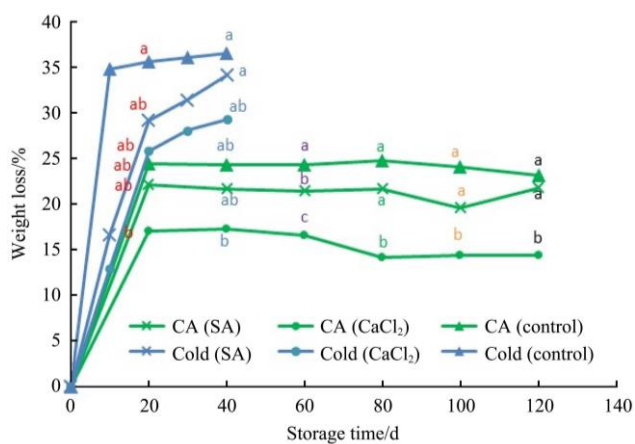
Barhi dates exhibit a considerable loss of weight through the first 20 d of storage; however, afterward the weight decreased at a lower rate Figure 1a. Nevertheless, in CA storage, the change in weight was lower with minor changes at some storage periods. It can be observed that for both cold and CA storage, the weight loss in the control samples was significantly higher than that of the treated samples. The lowest weight loss was observed for CaCl₂-dipped samples during the CA storage followed by the SA-dipped samples. After 40 d in cold storage, the control showed a 3.37% loss in weight, yet the percentages of weight loss of treated samples were 3.15% and 2.70% for SA and CaCl₂, respectively. Meanwhile, at the end of CA storage (120 d), the control showed a 2.14% loss in weight, and the percentage of weight loss of the treated samples were 1.33% and 2.01% for CaCl₂ and SA, respectively.

During the first 20 d, no significant differences were seen between the two dipping treatments for either cold storage or CA storage. However, the weight loss of the CaCl₂-treated samples in CA storage was significantly lower than that of the control samples in cold storage. On the 40th day in cold storage, significant differences were observed between the control and the SA-treated samples. Significant differences were found between the CaCl₂-treated samples and the other samples during the CA storage method after 60 d, 80 d, 100 d, and 120 d.

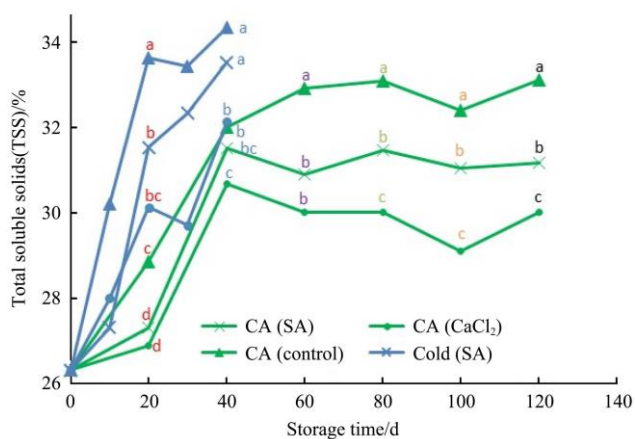
Generally, the loss in fruit weight is caused by the deficiency of moisture due to transpiration, respiration and vapor pressure deficit (VPD) among the adjacent air and the fruits. The loss in moisture causes a rapid rise in the concentration of sugars, leading to the maturation of the fruit^[21]. Dipping in CaCl₂ and SA restrain the removal of moisture through the fruit skin and postpone the respiration rate by constraining ethylene biosynthesis and hence reducing fruit weight loss^[13,22]. Dipping in CaCl₂ proved to be more effective in reducing weight loss as compared with dipping in SA or water (control). The effectiveness of CaCl₂ treatment in decreasing weight loss is due to the increase in moisture holding capacity and reduction in moisture evaporation^[23]. The obtained results for the weight loss are similar to those stated in previous studies for blackberry, raspberry and strawberry, apple, and peach fruits^[11,24,25].

3.2 Total soluble solids (TSS)

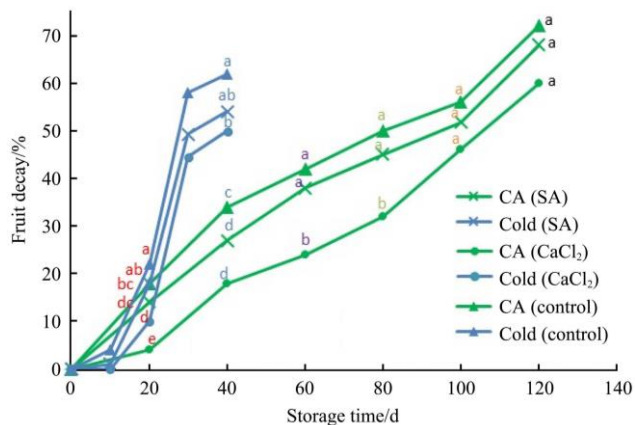
The TSS of the treated and control samples of Barhi dates increased with storage time during both storage methods Figure 2b. The smallest variations in TSS were apparent for the CaCl₂-dipped samples during CA storage. This might be due to the influence of calcium in reducing the ethylene production, respiration rate, and enzyme activity, thus, delaying fruit maturation and changes in color.



a.



b.



c.

Note: Means with different letters in treatment indicate significant differences between the groups in the vertical direction according to LSD test ($p \leq 0.05$) ($n=5$).

Figure 1 Changes in weight loss, TSS%, and fruit decay% in Barhi fruits as affected by pre-storage dipping in CaCl₂ and SA and by the time during cold and CA storage methods

At the end of the cold storage (40th day), TSS of the control sample increased by 30.5%, whereas, after 120 d in the CA storage the increase in TSS of the control sample was 25.8%. On the 40th day in the cold storage the increase in TSS of CaCl₂-treated samples was 22%, however, it was reduced to 14% after 60 d in the CA storage.

Through CA storage up to 60 d, the changes in TSS of the treated samples were not significantly different. However, the increases in the TSS values of the treated samples in cold storage was significantly higher than those in CA storage. After 80 d and until the end of CA storage, the variation in the TSS% of the

CaCl₂-treated samples was significantly lower than that of the other samples.

Hussain et al.^[24] reported that the increase in the TSS of fruits in storage is due to the moisture reduction and enzyme activity in changing complex polysaccharides into simple sugars. The reduced increase in the TSS of the treated samples could be attributed to dipping in CaCl₂ or SA, which makes a thin coating on the surface of the dates that reduces moisture and weakening the changing process. Analogous results were found in similar studies on jamun (*syzygiumcumini*skeels) fruits, strawberries, and apple fruits^[26-28].

3.3 Fruit decay

The percentage of fruit decay in treated and control samples increased with storage time during both cold and CA systems Figure 1c. The increase in fruit decay was higher during cold storage compared to CA storage for all samples.

During both storage methods, the highest fruit decay% was attained by the control samples, whereas the lowest fruit decay% was acquired by CaCl₂-treated dates. At the 40th day in cold storage, the fruit decay percentages of the control and the SA- and CaCl₂-treated samples were 62%, 54%, and 49%, respectively. However, in CA storage, fruit decay percentages of 72%, 68%, and 60%, respectively, were observed after 120 d. Post-harvest dipping in CaCl₂ of sugar apples confirmed an affirmative influence on delaying the biochemical and physiological processes that enhance fruit maturation^[29]. Zhang et al.^[14] stated that dipping in SA decreases fruit respiration and weight loss by closing tiny holes in the fruit skin, consequently, postponing maturation, senescence, and fruit decay during storage.

3.4 Fruit color

3.4.1 L, a, and b color values

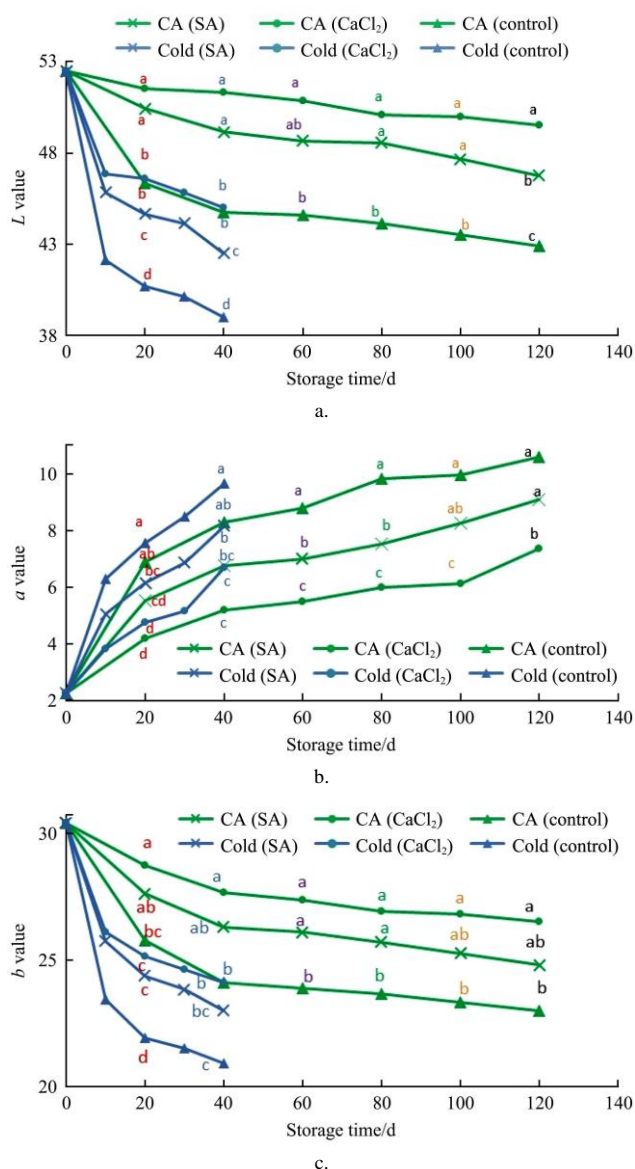
The means of the initial values of L, a, and b of the fresh Barhi dates were 52.48, 2.04, and 30.04, respectively; these high values indicate that fresh Barhi dates exhibited bright yellow skin color. The effects of CaCl₂ and SA dipping on the values of L, a, and b of the Barhi dates during cold and CA storage are presented in Figure 2.

Figures 2a and 2c show that the L and b values decreased for all samples during storage, illustrating that the skin color of the samples was becoming less bright and browner. The two figures indicate that L and b values decreased at a faster rate during the first 20 d in both CA and cold storage. Moreover, the L and b values for the SA-treated and the control samples in cold storage decreased significantly compared with their values in CA storage. The largest reduction in the L and b values was detected for the control in cold storage, while the smallest reduction in their values was observed for the CaCl₂-treated dates in CA storage. Figure 2b shows that, for all samples, the value of a rises with storage period for both storage systems. This demonstrates a more apparent redness in the color of the dates. The CaCl₂-treated dates in CA storage exhibited minimal changes in the values of parameter a. The noticed delay in the color change of the samples treated with CaCl₂ might be due to the retarding action of CaCl₂ on the synthesis of ethylene and, hence, the reduction in the respiration rate of the fruits^[9,11].

3.4.2 Derivative color parameters

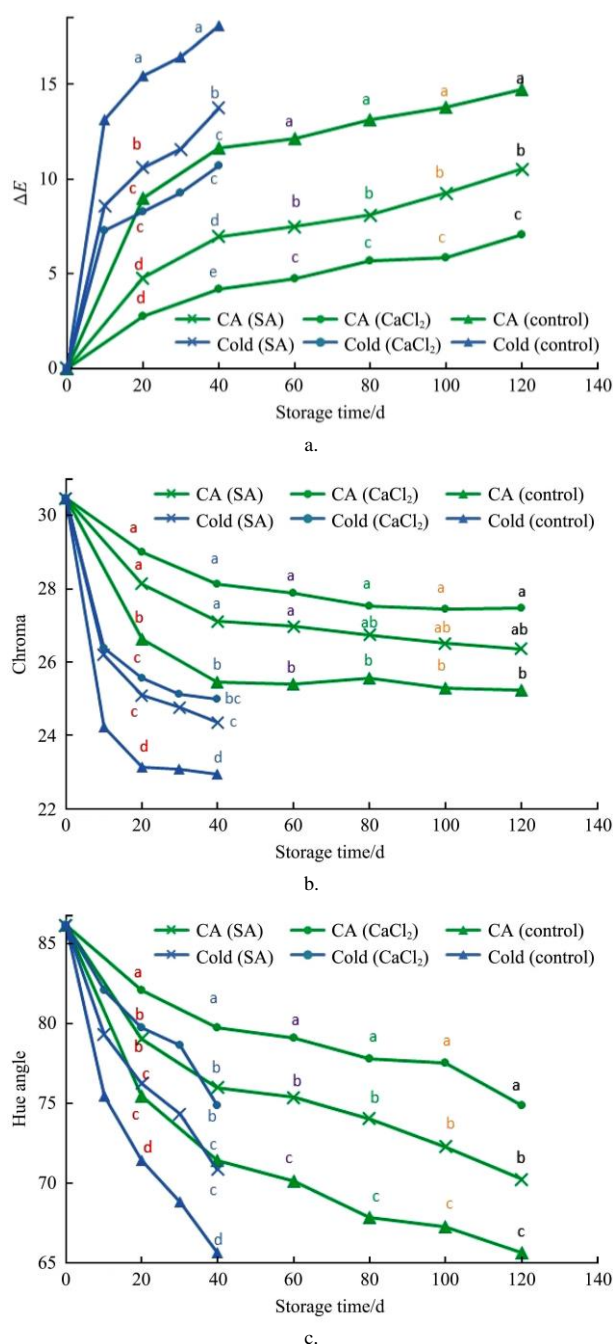
The changes in the derivative color parameters (ΔE , Chroma, and hue angle) of the treated and control Barhi dates during cold and CA storage are displayed in Figure 3. The total color difference (ΔE) is a colorimetric feature for describing color changes in the processed food. The Chroma parameter specifies

the color saturation degree, and it is comparable to its intensity. The hue angle is an additional factor for describing food color^[18]. As seen in Figure 3a, the total color difference (ΔE) increased with storage time during both storage systems for all samples. The ΔE values of all cold-stored samples are higher compared to those of CA-stored ones. This indicates the effectiveness of CA storage in preserving the color of the Barhi fruits compared to cold storage. At the end of the cold storage, the values of ΔE for the control, SA-treated, and CaCl_2 -treated dates were 18.07, 13.74, and 10.72, respectively. In contrast, after 120 d in CA storage ΔE values for the control, SA-treated, and CaCl_2 -treated dates were 14.70, 10.52, and 7.06, respectively. There were significant differences in the ΔE values of the tested samples within each storage technique. After 40 d of storage, significant differences in the ΔE values were observed between the same treatments in both storage methods. The ΔE values of the control in the CA storage were not significantly different from those of the CaCl_2 -treated samples in cold storage.



Note: Means with different letters in treatment indicate significant differences between the groups in the vertical direction according to LSD test ($p \leq 0.05$) ($n=5$).

Figure 2 Changes in the basic colour parameters of Barhi dates as affected by dipping in CaCl_2 and SA and by the time during cold and CA storage methods



Note: Means with different letters in treatment indicate significant differences between the groups in the vertical direction according to LSD test ($p \leq 0.05$) ($n=5$).

Figure 3 Changes in the derivative color parameters of Barhi dates as affected by dipping in CaCl_2 and SA and by the time during cold and CA storage methods

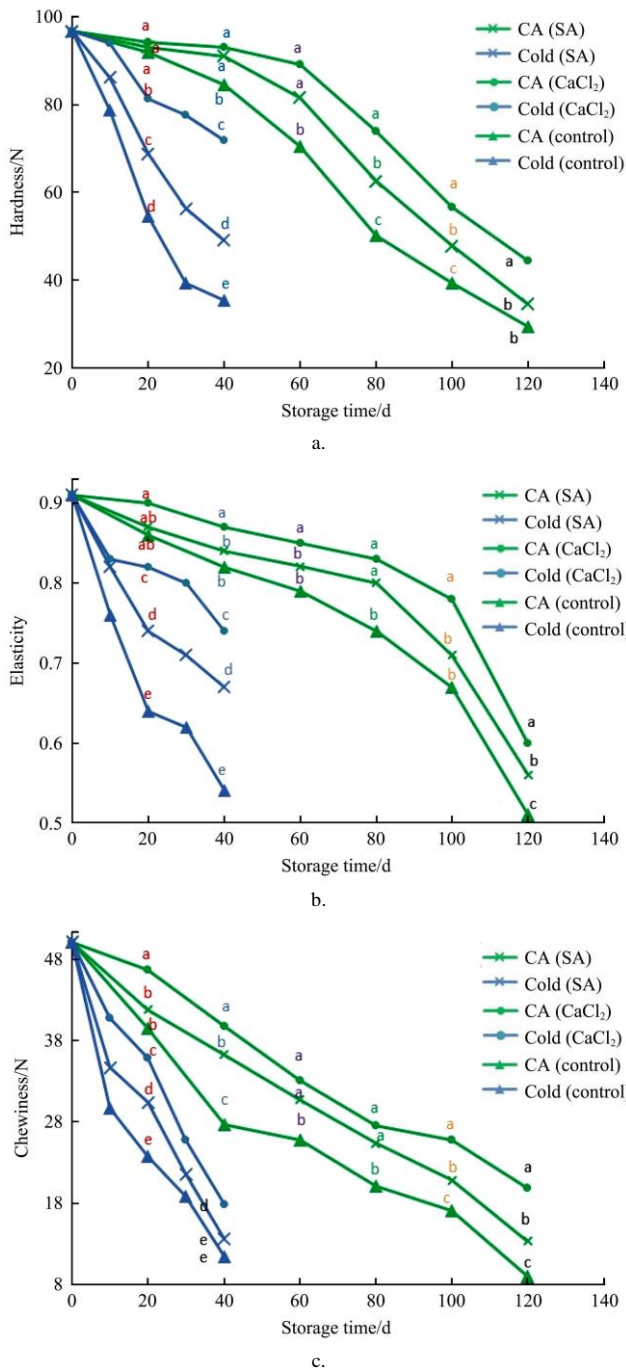
The initial mean values of Chroma and hue angle were 30.47 and 86.13, respectively. The values of Chroma and hue angle of all tested samples decreased with storage time for both storage techniques (Figures 3b and 3c). The largest decrease in Chroma and hue angle values was noticed for the control dates in cold storage, and the smallest decrease was observed for CaCl_2 -treated dates in CA storage. After the 40th day up to the completion of CA storage, the value of hue angle for the CaCl_2 -treated dates were significantly higher than the hue angle of all other samples. Significant differences were noticed between the Chroma values of the treated samples in CA storage and all samples in cold storage.

These results showed that dipping in CaCl_2 yielded the optimal outcome in preserving the color of Barhi dates during CA storage. The effectiveness of CaCl_2 treatment in preserving the color of

Barhi dates during storage can be attributed to the influence of calcium in delaying enzymatic actions, respiration rate, and ethylene production. These findings are compatible with other research studies that reported the beneficial effects of calcium post-harvest treatments in delaying the natural physiological and biochemical changes that initiate ripening and color change during low-temperature storage^[9,26].

3.5 Textural parameters

Fruit textural properties such as hardness, elasticity, and chewiness are very important parameters that affect consumer acceptance. The impact of CaCl₂- and SA-dipping treatments on these textural properties for the Barhi dates during cold and CA systems are shown in Figure 4.



Note: Means with different letters in treatment indicate significant differences between the groups in the vertical direction according to LSD test ($p \leq 0.05$) ($n=5$).

Figure 4 Changes in the textural parameters of Barhi dates as affected by dipping in CaCl₂ and SA and by the time during cold and CA storage methods

The fruit hardness initial mean value for the Barhi dates was 96.6 N. Figure 4a, shows that the hardness of the tested Barhi dates decreased with storage time for all treated and untreated samples. However, during cold storage, hardness was reduced at a higher rate than during CA storage. At the end of 40 d in cold storage, the hardness of the control decreased by 63%, compared to 26% for the CaCl₂-treated dates. At the end of 120 d in CA storage, the control hardness decreased by 69%, while that of the CaCl₂-treated dates decreased by 54%. The lowest decrease in fruit hardness during storage occurred for CaCl₂ treatment followed by SA treatment. Controlled atmosphere storage was significantly superior in maintaining the hardness of stored Barhi dates compared to cold storage. The hardness of the treated and control samples started to decrease significantly after 20 d in CA storage. Similarly, no significant differences between the CaCl₂- and SA-treated samples were observed after 40 d and 60 d, respectively, in CA storage. However, starting from the 80th day in CA storage, the reduction in hardness of CaCl₂-treated samples was significantly lower compared to other samples.

The fruit elasticity initial mean value for the Barhi dates was 0.88. From Figure 4b it is apparent that the fruit elasticity values of Barhi dates declined with time for all tested samples during storage. The lowest loss of elasticity was achieved by the dates dipped in CaCl₂ during CA storage. Meanwhile, the largest loss in elasticity was seen for the control during cold storage. The percentage losses of elasticity of the control, SA-, and CaCl₂-treated dates at the end of 40 d in cold storage were 42.0%, 27.3%, and 19.3%, respectively. However, the elasticity values of the control, SA-treated and CaCl₂-treated samples at the end of 120 d in CA storage were reduced by 45.5%, 39.8%, and 35.2%, respectively. At the 20th day in CA storage, the elasticity values of all stored samples were not significantly different. The elasticity values of all cold-stored samples were significantly lower compared to their equivalents in CA storage. Starting from the 40th day up to the last day in CA storage, the values of the elasticity for the CaCl₂-treated samples were significantly higher than those of other samples.

The chewiness initial mean value of the Barhi dates was 49.8 N. Figure 4c clearly shows that the chewiness value of the Barhi dates decreased with storage time for all treated and untreated samples during storage. The smallest reduction in chewiness was attained by the CaCl₂-treated dates, whereby the control attained the largest reduction during both storage systems. At the 40th day in cold storage, the chewiness of the control acquired a reduction of 77.6% in chewiness, compared to a reduction of 64.9% for the CaCl₂-treated dates. By the end of CA storage, the chewiness of the control had decreased by 82.6%. The lowest decrease in fruit chewiness was noted in the CaCl₂-treated dates during CA storage. The highest decrease was attained by the control in cold storage. CA storage was significantly superior in maintaining the stored fruit chewiness, compared to cold storage. The reduction in chewiness of the treated and control samples was not statistically different until the 20th day in CA storage. Likewise, no significant differences were seen between the CaCl₂- and SA-treated samples after 40 d and 60 d, respectively, in CA storage. Starting from the 80th day in CA storage, the reduction in chewiness of the CaCl₂-treated samples was significantly lower compared to the other samples.

The results as mentioned above show that dipping in CaCl₂ followed by dipping in SA preserved the texture of Barhi dates during storage compared to the control. This consequence could be attributed to that Calcium increases the fruit hardness by making the cells firm, postpone softening and reduces fruit decay^[30]. Also,

Calcium protects the cells from enzymes that ruined the cell walls^[31]. Similar results of the effect of CaCl₂ on preserving fruit texture were stated by other authors^[27,28]. Moreover, SA pretreatment maintenance of fruit texture has been known for some fruits and vegetables such as apple, orange, peach, banana, kiwifruit, and tomato^[12].

3.6 Sensory quality attributes

The sensorial outcomes for the chosen quality attributes of

Barhi dates as influenced by post-harvest dipping in CaCl₂/SA and time in cold and CA storage are given in Table 2. The sensorial initial mean scores for the quality attributes of the fresh dates ranged between 8.2 and 8.9 on a scale of 1-9, designating the high quality of the fresh Barhi dates. From the data in the Table 2, it is evident that the scores for all samples decreased with storage time during both cold and CA storages. This indicates the deterioration of Barhi date quality with storage time.

Table 2 Results on sensory quality attributes of Barhi fruits as affected by treatments and storage time during cold and controlled atmosphere storage, treatment means with different letters indicate significant differences according to LSD test (p-value ≤0.05) (n = 5)

Storage Method and Treatment		CA			Cold		
		Treatments			Treatments		
Time	measurements	Control	SA	Cacl ₂	Control	SA	Cacl ₂
0	Color	8.70±0.30a	8.70±0.30a	8.70±0.30a	8.70±0.30a	8.70±0.30a	8.70±0.30a
	Texture	8.40±0.80a	8.40±0.80a	8.40±0.80a	8.40±0.80a	8.40±0.80a	8.40±0.80a
	Taste	8.70±0.10a	8.70±0.10a	8.70±0.10a	8.70±0.10a	8.70±0.10a	8.70±0.10a
	Overall acceptance	8.40±0.40a	8.40±0.40a	8.40±0.40a	8.40±0.40a	8.40±0.40a	8.40±0.40a
10	Color				6.1±0.06b	6.9±0.21a	6.8±0.9ab
	Texture				3.9±0.48c	6.5±0.09b	6.9±0.07a
	Taste				4.5±0.26b	6.7±0.33a	6.7±0.49a
	Overall acceptance				3.6±0.36b	6.6±0.27a	6.7±0.41a
20	Color	4.9±0.11d	6.6±0.41b	7.3±0.66a	4.5±0.57d	5.4±0.57c	5.4±0.47c
	Texture	4.2±0.84d	6.0±0.98b	6.7±0.3a	3.3±0.82e	5.2±0.14b	5.9±0.67b
	Taste	4.6±0.36d	6.5±0.5b	7.2±0.77a	4.4±0.06d	5.9±0.77c	6.2±0.63bc
	Overall acceptance	4.5±0.54d	6.3±0.7b	7.0±0.99a	4.0±0.7d	5.3±0.2c	5.8±0.97bc
30	Color				3.0±0.1b	4.9±0.44a	5.6±0.96a
	Texture				2.2±0.62b	4.4±0.01a	5.0±0.77a
	Taste				3.0±0.26b	5.7±0.17a	5.8±0.01a
	Overall acceptance				2.9±0.28c	4.7±0.33b	5.7±0.14a
40	Color	3.6±0.38c	5.1±0.95b	6.8±0.2a	2.7±0.4d	3.6±0.95c	5.1±0.27b
	Texture	2.8±0.23bc	4.1±0.93a	4.5±0.47a	2.5±0.07c	2.9±0.78b	3.2±0.5b
	Taste	4.2±0.85c	5.7±0.34a	6.3±0.7a	2.7±0.07d	3.9±0.15c	4.9±0.31b
	Overall acceptance	3.1±0.91cd	4.6±0.43b	5.8±0.21a	2.6±0.24d	3.8±0.9c	5.1±0.43ab
60	Color	3.3±0.72c	4.5±0.54b	5.6±0.38a			
	Texture	2.5±0.5b	2.9±0.12ab	3.5±0.5a			
	Taste	3.3±0.71b	4.5±0.54a	5.0±0.04a			
	Overall acceptance	3.1±0.86c	4.0±0.04b	5.1±0.91a			
80	Color	2.7±0.25b	4.1±0.9a	5.0±0.04a			
	Texture	1.3±0.69b	2.0±0.04b	3.2±0.8a			
	Taste	3.4±0.6b	4.6±0.35a	5.2±0.83a			
	Overall acceptance	2.4±0.63b	3.9±0.1a	4.4±0.6a			
100	Color	2.6±0.42b	4.4±0.61a	4.9±0.12a			
	Texture	0.8±0.24b	2.3±0.7a	2.8±0.23a			
	Taste	3.0±0.97b	4.6±0.39a	5.1±0.87a			
	Overall acceptance	1.7±0.34b	3.1±0.92a	3.4±0.58a			
120	Color	2.9±0.05b	4.0±0.97a	4.5±0.52a			
	Texture	1.8±0.18b	2.5±0.51ab	3.1±0.9a			
	Taste	3.0±0.04c	4.7±0.3b	6.2±0.81a			
	Overall acceptance	1.9±0.06b	2.2±0.78ab	2.5±0.53a			

At the end of cold storage (40th day), the average overall acceptance scores for the control, SA-treated, and CaCl₂-treated dates were 2.6, 3.8, and 5.1, respectively, on a scale of 1-9. This demonstrates a lower quality of fruit, especially with control and

SA-treated samples. Meanwhile, at the 40th day in CA storage, the scores were 3.1, 4.6, and 5.8, respectively. These data indicate that samples stored in CA are better in quality compared to those in cold storage. At the 120th day in CA storage, the overall

acceptance scores for the control, CaCl₂-treated, and SA-treated dates were 1.9, 2.2, and 2.5, respectively, indicating poor quality for all samples.

The highest sensory quality scores were achieved by CaCl₂-treated dates in CA storage. This sensory evaluation is in agreement with other experimental results in that post-harvest dipping in CaCl₂ with CA storage is effective in preserving the quality of Barhi dates at the Khalal stage of maturity and in delaying the ripening of the fruits. The lowest scores were obtained by the control at the end of the cold storage and also at the end of the CA storage. This may possibly be due to the increased enzyme activities, reduced TSS%, and softening of the texture of Barhi dates during the long storage time^[9,11,24,29].

4 Conclusions

It can be concluded that dipping in 2% of CaCl₂ aqueous solution or SA (2.0 mmol/L) as postharvest treatments help to preserve the quality and enhanced storability of Barhi dates at Khalal maturity stage during cold and controlled atmosphere storage. Weight loss%, fruit decay%, TSS% were decreased with advancing of storage time for treated samples compared to untreated samples (control) during both storage methods. Postharvest dipping in 2% CaCl₂ gave the best results in conserving the color and texture of Barhi dates during storage, especially in the CA storage. The sensorial quality of Barhi dates treated with CaCl₂ was relatively satisfactory after 40 d in controlled atmosphere storage.

Acknowledgements

The authors are grateful to the Deanship of Scientific Research, King Saud University for funding through the Vice Deanship of Scientific Research Chairs.

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