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Effect of Natural *Aloe Vera* Gel Coating Combined with Calcium Chloride and Citric Acid Treatments on Ggrape (*Vitis vinifera* L. Cv. Askari) Quality during Storage

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Abstract A novel edible coating based on natural Aloe vera gel in combination with calcium chloride (2%) and citric acid (1%) was used as a mean of preservation to maintain the quality and safety in table grape (Vitis vinifera L. cv. Askari) during cold storage at 4°C temperature and 85 ± 5 % relative humidity for 35 days. Coated clusters delayed the increase in weight loss and soluble solids content, retained greater ascorbic acid and titratable acidity contents than control. Moreover, the sensory analyses revealed beneficial effects in terms of delaying rachis browning and dehydration, which was significantly lower in treated than control fruit.

Keywords: *table grape, edible coating, Aloe vera, calcium chloride, citric acid, Postharvest quality*

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1. Introduction

Table grape is a highly perishable, non-climacteric fruit. Table grapes have severe problems since acceleration of quality loss occurs during postharvest storage due to weight loss by dehydration, tissue softening, rachis browning browning and anomalous aromas attributable to over-ripeness accompanied in most cases with high incidence of berry decay (Crisosto *et al.*, 2002; Crisosto *et al.*, 2002; Guillén *et al.*, 2007), which lead to a reduction of shelf life. However, the use of a combination of pesticides, the development of fungicide-resistant strains, and the public's concern for human health and environmental pollution have stimulated the search for new strategies as alternative tools for controlling postharvest decay.

Edible coatings create a modified atmosphere around the fruit by providing a semipermeable barrier to water vapor and gases, and their use offers an attractive alternative to film packaging due to their environmentally friendly characteristic (Rojas-Argudo *et al.*, 2005). Different compounds have mainly been used as edible coatings. *Aloe vera* L. gel is a novel edible coating for organic fruit storage technology. Application of *A. vera* gel coating has been reported to extend shelf life by delaying postharvest loss of quality in sweet cherries (Martínez-Romero *et al.*, 2006) and table grapes (Serrano *et al.*, 2006).

It is well known that calcium plays a major role in maintaining the quality of fruit and vegetable. Preharvest and postharvest treatments with calcium salts have been effective in controlling several physiological disorders, reducing the incidence of fungal pathogens and maintaining fruit firmness (Bakshi *et al.*, 2005). Calcium ions cross-link free carboxyl groups on adjacent polygalacturonate chains present in the middle lamella of the plant cell wall contributing to cell adhesion and cohesion.

Citric acid (CA) is an anti-browning agent, which prevents polyphenol oxidase (PPO) by suppressing the food pH and binding the Cu^{2+} in an active site of PPO to form an inactive complex (Martinez and Whitaker, 1995). It has also been widely used in the food industries for controlling the browning. Although applying CA as a dipping solution has been reported in postharvest fruits with very satisfactory results for fruits such as longan (Sardsud *et al.*, 2003; Whangchai *et al.*, 2006) and litchi (Terdbaramee *et al.*, 2002).

No research has been reported on the effects of natural *A. vera* applied as an edible coating combined with calcium chloride and citric acid on shelf life and the fruit quality attributes of grape, so that the objective of this study was to determine the effects of *A. vera* combined with calcium chloride and citric acid on grape (*Vitis vinifera* L. cv. Askari) storage capability, functional properties and quality attributes.

2. Materials and Methods

2.1. Plant Material

Table grapes (*Vitis vinifera* L. cv. Askari) were harvested from a commercial orchard in Meimand (Shiraz, Iran) in Aguest. At the laboratory, harvested fruits were selected to obtain homogeneous batches based on color, size, absence of injuries, and healthy greenish rachises. Clusters were cut to obtain 180 samples ranging from 150 to 170 grams.

2.2. Fruits Coating

60 of grape clusters were treated with *A. vera* gel combined with calcium chloride (2%) (ACa) and the 60 of grape clusters were treated with *A. vera* combined with CA (1%) (AC). Treatment was performed by immersion during 5 min with a solution of *A. vera* diluted 1:3 with distilled water. 60 of grape clusters were immersed in distilled water and served as control. Following the treatment, all clusters were air-dried during 60 min before storage at 4°C and 85 ± 5 % relative humidity (RH) for 35 days. There were 4 replications for each treatment containing 3 clusters. Thirteen clusters for each treatment were taken after 7, 14, 21, 28 and 35 days for quality evaluation and following analysis.

2.3. Weight Loss (WL)

The percentage of weight loss was determined according to the following equation:

$$\%WL(t) = \frac{W_{\circ} - W_t}{W_{\circ}} \times 100$$

Where $W_{\circ}$ is the initial weight and W_t is the weight of fruit after various storage times.

2.4. Soluble Solids Content (SSC) and Total Acidity (TA)

SSC was determined using a Refractometer (ATAGO, Tokyo, Japan) at 20°C and expressed as percentage. TA was determined in quadricate by titration with 0.1 N NaOH up to pH 8.1, using 1 mL of diluted juice in 25 mL of distilled water.

2.5. Ascorbic Acid Content

Ascorbic acid content was performed according to the method of Klein and Perry (1982). The fruits (0.1 g) were extracted with 10 mL of 1% metaphosphoric acid. Then, the fruit extracts were filtered, the filtrate (1 mL) was added to 9 mL of 50 mM 2, 6-dichloroindophenol (DIP), and the absorbance was read at 515 nm with a WVP model spectrophotometer (made in UK).

2.6. Decay and Rachies Browning Assessment

Symptoms of dehydration and browning for stems and decay severity of a single grape fruit in the bunch were evaluated on a ranked scale of 1–5, where 1= absence of these symptoms, 2= slight occurrence, 3= moderate, 4= severe, and 5= extremely severe browning and dehydration, for each treatment and sampling date, judges were served (n = 10).

2.7. Statistical Analysis

Data were subjected to analysis of variance (GLM). Sources of variation were time of storage and treatments, and the interaction of treatment × storage time. Mean comparisons were performed using the Duncan's test to examine if differences between treatments and storage time were significant at $P < 0.05$. All analyses were performed with SAS software package v. 9.1 for windows.

3. Results and Discussion

3.1. Weight Loss

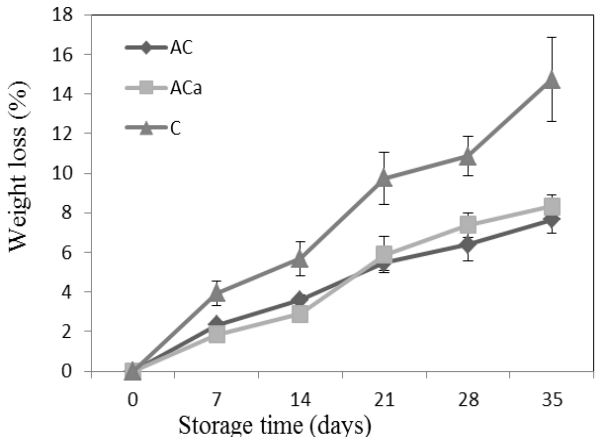

Figure 1. Cumulative weight loss during cold storage (4°C) of control (C) and *A. vera*-coated with calcium (AC) chloride and citric acid (ACa) table grapes clusters. Data are the mean ± SE

A. vera coating combined with calcium chloride and CA treatment significantly decreased weight loss and there was no significant difference between ACa and AC treatments (P > 0.05). In fact, Coating the grape with ACa and AC is clearly effective in conferring a physical barrier to moisture loss and therefore retarding dehydration and fruit shriveling (Figure 1). This positive effect of edible coatings is based on their hygroscopic properties, which enables formation of a water barrier between the fruit and the environment, and thus avoiding its external transference (Morillon *et al.*, 2002). The percentage of weight loss was double in control (14-15%) compared with that in *Aloe*-treated with calcium chloride and CA fruits (below 8%) after 35 days at 4°C. Calcium dip applications have shown to be effective in terms of membrane functionality and integrity maintenance, with lower losses of phospholipids and proteins and reduced ion leakage (Lester and Grusak, 1999) and the inclusion of CA, in the coating formulation, has lowered, to a certain extent, the hydrophobicity provided (Ayranci and Tunc, 2004), which could be responsible for the lower weight loss found in ACa-treated and AC-treated grape. As other edible coatings, *A. vera* gel prevented moisture loss and controlled respiratory gases exchange (Valverde *et al.*, 2005).

3.2. Titratable Acidity and Soluble Solids Content (SSC)

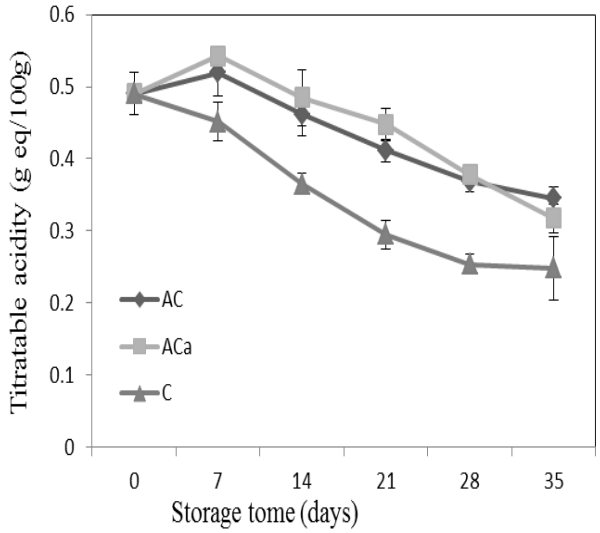

Figure 2. Change in TA during cold storage (4°C) of control (C) and *A. vera*-coated with calcium (AC) chloride and citric acid (ACa) table grapes clusters. Data are the mean ± SE

TA was higher in fruits coated with AC and ACa compared with control fruits and the TA of uncoated fruits fell slightly toward the end of the storage period (Figure 2). No significant changes were observed in the TA of coated fruits throughout the storage period. TA of *A. vera* coated sweet cherry (Martínez-Romero *et al.*, 2003) and grapes (Valverde *et al.*, 2005) kept under cold storage has been reported to decrease with time but to a lesser extent than that of uncoated fruits. It is also consistent with the works of García *et al.* (1996) and Hernández-Muñoz *et al.* (2006) that reported higher TA of calcium-dipped strawberries compared to untreated fruits stored at 18°C. The higher TA found in fruits coated with AC in this research is consistent with the works of Caro and Joas (2005) and Apai *et al.* (2009).

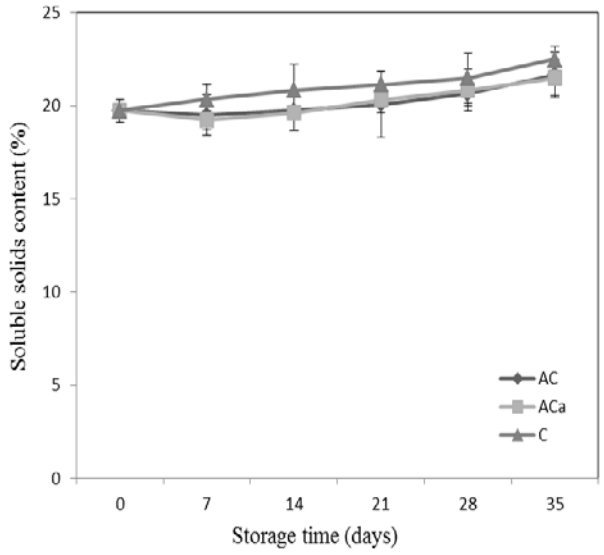

Figure 3. Changes in soluble solids content of control (C) and *A. vera*-coated with calcium (AC) chloride and citric acid (ACa) table grapes clusters. Data are the mean ± SE

Higher values for SSC were observed for fruits coated with AC and ACa compared with control fruits while no significant differences were observed in the variously coated samples (Figure 3). *A. vera* led to a lower increase in SSC, which indicated that control fruits presented a more pronounced maturation development than coated berries that could be related to the higher respiration rate found in uncoated fruits. In addition, the *A. vera* coating could produce a modification of the internal atmosphere, showing similar effects as modified atmosphere packaging (MAP) (Martínez-Romero *et al.*, 2003). Uncoated grapes had higher SCC due to higher water/weight loss.

3.3. Ascorbic Acid

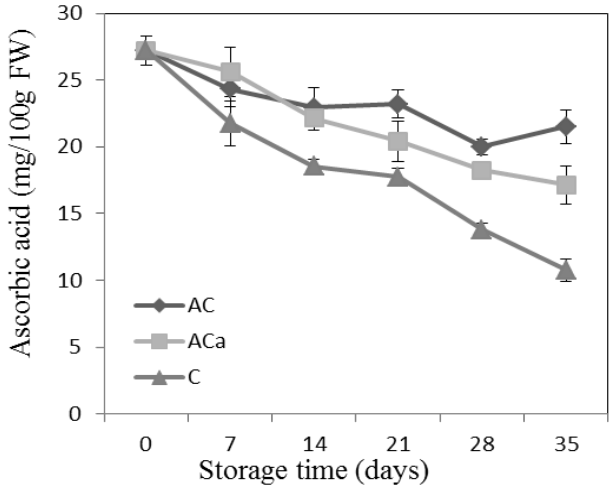

Figure 4. Ascorbic acid content during cold storage (4°C) of control (C) and *A. vera*-coated with calcium (AC) chloride and citric acid (ACa) table grapes clusters. Data are the mean ± SE

Ascorbic acid (AA) content of control samples declined significantly compared to coated samples. The grapes coated with AC had a higher AA content than the other treatments or the control. The initial AA content of both coated and uncoated grapes was 27.2 mg 100 g $^{-1}$.FW. After 35 d, AA contents in samples coated with AC and ACa were 19.02 and 17.1 mg 100 g $^{-1}$. FW whereas those in uncoated samples were 10.7 mg.100 g $^{-1}$.FW. The use of polysaccharide-based edible coatings including antibrowning agents significantly reduced AA loss of grapes during storage (Figure 4). Possible reasons for ascorbic acid losses during storage are autoxidation, which occurs spontaneously when the AA combine with oxygen in the air (Owusu - Yaw *et al.*, 1988). Coatings serve as a protective layer and control the permeability of O_2 and CO_2, thus decreasing the autoxidation of AA. The lowering of AA loss of foods with coatings containing antioxidants (CA) can be attributed to the low oxygen permeability (OP) of these coatings keeping oxygen away from the food delays the deteriorative oxidation reaction of AA (Ayranci and Tunc, 2003). Ayranci and Tunc (2004) reported that inclusion of CA in the coating formulation as antioxidant lowered the AA loss.

3.4. Decay and Rachis Browning

Results indicated moderate-severe symptoms of dehydration and browning in control 35 days at 4°C (scores < 3) and slight for those stems treated with *A. vera* gel even at the last sampling date (Figure 5). All coated samples markedly decreased decay index ($P < 0.05$) and AC treatment had the best effect on decay control panelists evaluated the visual aspect of the rachis and gave

the highest scores to those rachises of control clusters, which became significantly different from 7th day of cold storage compared to treated clusters and especially during the subsequent periods of storage (Figure 6). These results indicated severe symptoms of dehydration and browning in control rachises after 14 days at 4°C (scores > 3) and slight-moderate effects for those clusters treated with *A. vera* gel after 35 days of cold storage. In the present work, *A. vera* gel combined with CA and calcium chloride was effective in reducing microorganism proliferation in table grape. Stem browning typically developed during sweet cherry storage as has been associated with fruit ripening (Clayton *et al.*, 2003) and also due to dehydration (Schick and Toivonen, 2002). Thus, the effect of *A. vera* coating in delaying the quality loss of stems could be attributed to its effect on the inhibition of water diffusion and in turn, stem desiccation and browning. The results according to reports also showed a higher capacity in browning control when a combination of different edible coatings and antibrowning agents were applied on fresh products (Baldwin *et al.*, 1996; Lee *et al.*, 2003; Rojas-Graü *et al.*, 2007; Lin *et al.*, 2008).

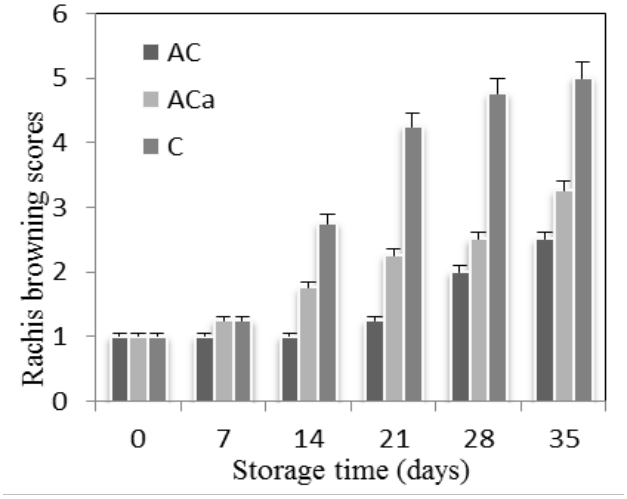

Figure 5. Scores for sensory analysis during of storage at 4°C of control (C) and *A. vera*-coated with calcium (AC) chloride and citric acid (ACa) table grapes clusters. Data are the mean ± SE of scores made by 10 judges in five cluster from each treatment

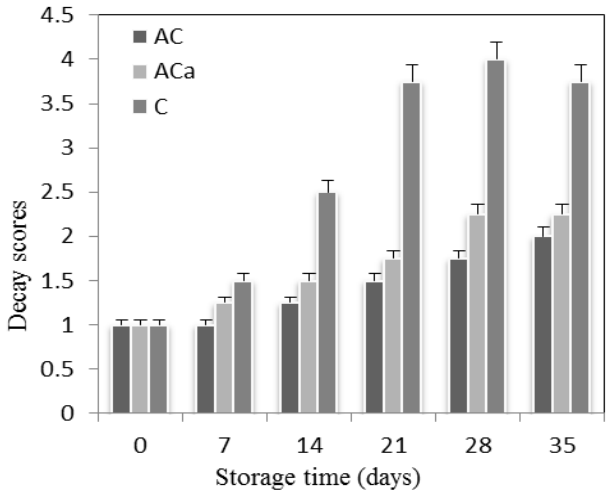

Figure 6. Scores for decay berries during storage at 4°C of control (C) and *A. vera*-coated with calcium (AC) chloride and citric acid (ACa) table grapes clusters. Data are the mean ± SE

4. Conclusions

Comparing with the uncoated table grapes, all the coated fruits showed significantly reduced weight loss ($p < 0.05$) and delayed changes in the ripening parameters such as SSC, TA and AA levels ($p < 0.05$). In addition, the *A. vera* treatments combined with calcium chloride and CA led to rachises with better freshness without browning symptoms, and lower decay incidence after 35 days of cold storage. Taking into account the overall obtained results, we recommend the use of *A. vera* in combined with calcium chloride and CA coating to maintain the quality of table grapes during long-term cold storage.

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