



## Influence of edible coatings on postharvest quality of fresh Chinese jujube fruits during refrigerated storage

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### ABSTRACT

Jujube fruits have a short shelf life due to its perishable nature. Preservation of jujube quality is a big challenge. Edible coatings have been used for centuries in the food industry as an effective method to preserve food products, enhance shelf life and prevent loss of firmness and moisture in fresh fruits. However, little information is available on the overall quality attributes of Chinese jujube fruits influenced by edible coatings. Hence, the influence of different edible coatings including Aloe vera gel (AV) (33 and 50% v/v), carboxymethyl cellulose (CMC) and pectin (1, 1.5 and 2% w/v) was studied on fresh jujube quality during 40 days of refrigerated storage at 4 °C. The results showed that weight loss was approximately reduced by 30% in coated jujubes with Aloe vera 33% v/v or 1.5% w/v pectin after 40 days compared to uncoated control. Uncoated fruits presented a higher and significant decay after 40 days of storage than other coating treatments. Results also indicated that the coatings with 50% v/v Aloe vera, 1 and 2% w/v CMC caused a higher and significant TA in jujube fruits, and preserved sensory acceptability as well as improved appearance quality of fruits compared to uncoated fruit. In general, coated fruit with Aloe vera at both concentrations and CMC at 1 and 1.5% after 40 days of refrigerated storage maintained the quality of jujube fruits better than control.

## INTRODUCTION

Jujube tree (*Ziziphus jujuba* Mill), is one of the invaluable plants, widely cultivated in Asia, especially in China, America and Europe (Wang et al., 2016), mostly due to nutritional and medicinal properties of its fruits. However, after harvest jujube fruits are susceptible to different biochemical and quality changes. These changes can be increased mainly by loss of water and therefore the storage life is usually short at room temperature (Baomeng et al., 2014). Hence, it is important to maintain the quality of fresh jujube fruits by preservation methods for extending its postharvest life.

In recent years, studies regarding the postharvest technologies of jujube mostly have focused on nano-packaging (Hongmei et al., 2009) and chemical treatments like 1-MCP and gibberellic acid (Weibo et al., 2004). However, the packaging is used for preservation of fresh horticultural crops as it is a cheaper and safe strategy than most chemical treatments. Nevertheless, due to environmental pollution of used films; recently different edible coatings are used to maintain fruit quality and conservations because of their environmentally friendly nature (Pramod et al., 2016). They act as barriers to oxygen and moisture and also against external factors during handling and storage, and thus improve fruit safety and retard deterioration. Ciolacu et al. (2014) noted that using edible coatings in fruits improved quality, extended storage life, and retarded water loss.

Among different kinds of edible coatings, aloe vera gel (AV), carboxymethyl cellulose (CMC) and pectin (PE), are some of the popular and safe coatings that can be used as an alternative to packaging and chemical treatments (Carneiro-da-Cunha et al., 2009; Rodriguez et al., 2010; Vega-Gálvez et al., 2011). Polysaccharide-based coatings like CMC and PE are colorless, tasteless, and odorless, and can be used as fruit coating to extend the shelf life of fruits, significantly reducing dehydration and darkening of the surface (Dang et al., 2008). Aloe vera is also a valuable source of antioxidants and antimicrobial agents (Vega-Gálvez et al., 2011). Hence, it is used in food and pharmaceutical industries (Rodriguez et al., 2010). Therefore, there is great interest amongst many researchers to investigate regarding the potential of these coatings for maintaining the postharvest quality and extending the shelf life of both whole and fresh-cut fruits as recently reported in different fruits. For example; aloe vera in pomegranate (Sadat Hosseini et al., 2017), strawberry (Sogvar et al., 2016) and blueberry (Vieira et al., 2016), carboxymethyl cellulose in apple (Saba & Sogvar, 2016), citrus (Arnon et al., 2015) and avocado (Tesfay & Magwaza, 2017), and pectin in apple (Guerreiro et al., 2017), cantaloupe (Koh et al., 2017), and persimmon (Sanchís et al., 2016). However, little information is available regarding the effects of these coatings on jujube fruit. There are only limited reports about the effects of edible coatings in jujube, for example, sodium alginate, glycerol and sunflower oil in Chinese winter jujube (Zhang et al., 2016) or chitosan in jujube (Zhang et al., 2014). Only in a study of jujube, the positive effect of Aloe vera gel on Indian jujube fruit quality was reported by Padmaja and Bosco (2014), and no information is available about the effect of AV gel, CMC and PE edible coatings on Chinese jujube fruit. Therefore, the objectives of the study were to examine the effects of Aloe vera gel, carboxymethyl cellulose, and pectin coatings on quality improvement, losses reduction, and safety of fresh Chinese jujube fruit.

## MATERIALS AND METHODS

### Plant material and coating treatments

Fresh Jujube (*Ziziphus jujuba* Mill.) fruits were manually picked at fully mature stage (red color) from a private garden in Birjand, South Khorasan, Iran, early in August 2015. Fruits were then transported to the postharvest laboratory within a day and stored at  $4 \pm 1$  °C for 2 days until processing. Thereafter, fruits were selected for their uniformity in size, shape and as well as the lack of injuries, pest and disease symptoms. Each treatment comprised four bags as replications, each containing 20 fruit (a total of 80 fruit per treatment). Fruits were dipped for 3 min into prepared solutions of Aloe vera gel (33 and 50% v/v), carboxymethyl cellulose (1, 1.5 and 2% w/v), pectin (1, 1.5 and 2% w/v) or distilled water as untreated (control). Thereafter, all treated fruit were air-dried at room temperature for 1 h, then placed in low-density polyethylene (LDPE) bags 0.02 mm thickness and stored at  $4 \pm 1$  °C with 80% relative humidity. Fruits were sampled at 0, 10, 20, 30 and 40 days of storage for physico-chemical assessments, while antioxidant, decay and sensory evaluations were done at days 0 and 40 of storage.

### **AV gel, CMC and pectin preparation**

Mature leaves of Aloe vera plant were prepared from the market and washed with an ethanol solution of 50% (v/v). The Aloe vera gel was then separated from leave and prepared according to [Sogvar et al. \(2016\)](#) method. The fruit was dipped at 20 °C for 3 min in AV diluted 1:2 and 1:1 with distilled water similar to previous studies by [Hassanpour \(2015\)](#).

The CMC coating was prepared by dissolving CMC (Sunruz, Japan) in distilled water at 75 °C for 15 min to obtain final concentrations of 1, 1.5 and 2% (w/v) CMC.

The pectin solutions 1, 1.5 and 2% (w/v) were prepared by mixing pectin (Sigma, USA) in distilled water (12 h at 30 °C) as described in [Maftoonazad et al. \(2007\)](#). The solution was then cooled to room temperature before use

### **Physicochemical analysis**

#### ***Total soluble solids (TSS), Titratable acidity (TA) and pH***

The TSS was determined with a hand-held refractometer (RF 10, °Brix 0–32, Extech Co., USA) at 25 °C, and expressed as °Brix. Titratable acidity (TA) was determined by titration of juice with NaOH and the pH was measured using a digital pH meter ([Sadat Hosseini et al., 2017](#)).

#### ***Firmness***

The firmness of fruits was evaluated by a digital penetrometer and data showed as Newton ([Sadat Hosseini et al., 2017](#)).

#### ***Weight loss***

To determine weight loss (WL), 20 fruits per replicate were weighted at harvest time (day 0) and after each storage period (day 10, 20, 30, and 40) and calculated according to the method described in [Sadat Hosseini et al. \(2017\)](#).

#### ***Vitamin C***

Vitamin C content was determined using 2, 6-dichlorophenol indophenols ([Nielsen, 2010](#)). The results were expressed as mg 100 g<sup>-1</sup> of fruit fresh weight.

#### ***Total antioxidant activity (TAA) assay***

DPPH method was used to measure the antioxidant activities of jujube fruit (Blois, 1958) as described by Moradinezhad et al. (2016).

### Decay percentage

To determine fruit decay, any fruit showing the signs of fungal growth and mealiness during cold storage at  $4\pm1$  °C was considered as decayed. Decay percentage was calculated according to Hussain et al. (2015) method.

### Overall acceptability

Overall acceptability based on flesh taste, texture and color were evaluated by a panel of nine assessors after 40 days of cold storage. The evaluation was done on a hedonic scale of 1–9, where score 9 indicated as like extremely (evident harvest freshness and firmness with light green color and absence of off-flavor) and score 1 considered as dislike extremely (dislike completely, very soft fruits with brown flesh and low juiciness) (Moradinezhad et al., 2013).

### Color measurement

The skin color of jujube fruits was measured by using colormeter (TES-135A, Taiwan) and recorded as L\* (lightness), a\* (-greenness to +redness) and b\* (-blueness to +yellowness).

### Statistical analysis

The experiment was conducted using a completely randomized design as factorial, with four replications. Data were subjected to analysis of variance (ANOVA). The difference between means compared using LSD test at  $P\leq0.05$ . All analyses were performed with GenStat program (version 12, 2010, VSN International, Ltd., UK).

## RESULTS AND DISCUSSION

### TSS, TA and pH

The effect of cold storage and coating treatments during 40 days of cold storage are shown in Table 1. The TSS, TA, and pH of the jujube fruits at the beginning of the experiment (day 0) were not significantly affected by coating treatments (Table 1). The TSS in all treatments remained stable with no significant differences between coating treatments over storage time. This was in contrast to findings of Padmaja and Bosco (2014) who mention TSS significantly increased in control and Aloe vera coated Indian jujube (*Zizyphus mauritiana*) during cold storage which is usually stated as a climacteric fruit (Abbas & Saggar, 1989) and ranged from 22 to 24.4 °Brix. The TSS increases in all the fruits especially in climacteric fruits as the fruit ripens there carbohydrates were converted to simple sugars, but Chinese jujubes used in our case are a non-climacteric fruit (Kader et al., 1982) and thus, only small changes of TSS are expected. Nevertheless, TA values decreased in all treatments along storage time. This is in agreement with findings of previous studies (Ding et al., 1998; Valero & Serrano, 2010). They stated that organic acid content in stored fruit decreases during ripening and storage because organic acids are used as substrates for respiratory metabolism. At day 10 significant differences were found in the TA of coated jujube fruits (Table 1). The highest TA was observed in Aloe vera 50%, however, at day 20 of storage, TA value was higher in Aloe vera 30 and 50% and CMC 1% and 2%, while at day 30 again the higher TA was obtained in Aloe vera 50%, which was not significantly different with coated fruit with pectin 1.5 and 2%. After 40 days of storage, no significant differences were found in TA among coating treatments. The results show that using edible coatings especially Aloe vera and CMC was effective to slow down TA reduction until day 30 of storage, which means these coatings can

control ripening and senescence of jujube fruits. Aloe vera and CMC coatings could produce a modification of the internal atmosphere, lead to similar effects as modified atmosphere storage (MAP) (Martinez-Romero et al., 2006; Vargas et al., 2008) and act as an oxygen barrier and consequently slow down respiration rate of fruit (Oluwaseun et al., 2013). The pH of coated fruits changed slightly and was higher in CMC and pectin than Aloe vera treatment at day 0 (Table 1). A similar trend was observed until day 30; however, at day 40 no significant differences were obtained in pH among coating treatments.

### Firmness

Data analysis showed that there was no significant difference in the firmness of jujube fruits treated with coating treatments at day 0 of storage (Table 2). Further, it is clear from the Table 2 that the maximum retention of firmness (1.57 N) was obtained with Aloe vera 50% coating at day 10 of storage. This is in agreement with the findings of Padmaja and Bosco (2014) who mention that Indian jujube fruit treated with Aloe-pectin had greater firmness than control. Lower firmness was mainly due to ripening or fruit softening (Ezhilarasi & Tamilmani, 2009), due to the degradation of pectin (Hongmei et al., 2009). Nevertheless, at day 20 coated fruits with CMC 1% had the higher firmness (1.27 N), which did not significantly different with pectin at levels 1 and 1.5% and Aloe vera 50%. Also, suggesting CMC and pectin coatings in proper concentrations as useful edible coatings in Chinese jujube fruits. Significant and beneficial effects of CMC and pectin coatings in maintaining the higher values of firmness have been reported previously in different fruits (Hussain et al., 2015; Saba et al., 2015). At day 40 of storage, no significant difference was found in the firmness of jujube fruits treated with coating treatments, and as expected firmness decreased during storage time.

### Weight loss

Fruit weight loss increased through storage across all treatments. After 30 days of storage, no significant differences were observed in weight loss of coated and uncoated control fruits (Table 2). However, at day 40 of storage, coated fruits with Aloe vera 33%, pectin 1 and 1.5% showed the higher weight loss compared to the control and other treatments. In other words, at the end of the storage period, jujube fruits treated with CMC at all concentrations, pectin 2% and Aloe vera 50% showed less weight loss compared to other coating treatments. Generally, fruit weight loss during cold storage is expected and was also reported in different coated fruits (Guerreiro et al., 2015; Hussain et al., 2015; Shin et al., 2008). In a study of Indian Jujube, (Padmaja & Bosco, 2014) they noted that weight loss was significantly higher in control than in Aloe-pectin treated fruits, which is in contrary with our results. They were packed fruits in low-density polyethylene (LDPE) bags with a small hole of 0.5 cm. Thus, differences in weight loss may be related to the different water vapor permeability of the polysaccharides and their concentrations and/or additives used and also the effect of different packaging method on water loss. Due to transpiration and respiration processes, fruit weight loss occurred during storage in both treated and untreated fruits (control) (Hongmei et al., 2009).

**Table 1.** Total soluble solids (TSS), titratable acidity (TA) and pH of uncoated (control) and coated jujube fruit with different concentrations of aloe vera (AV), carboxymethyl cellulose (CMC) and pectin (PE) during 40 days of storage at  $4 \pm 1$  °C

| Treatment | TSS (%)                       |                               |                               |                                |                              |
|-----------|-------------------------------|-------------------------------|-------------------------------|--------------------------------|------------------------------|
|           | Day 0                         | Day 10                        | Day 20                        | Day 30                         | Day 40                       |
| Control   | 8.50 $\pm$ 0.36 <sup>a†</sup> | 7.82 $\pm$ 0.29 <sup>a</sup>  | 6.50 $\pm$ 0.21 <sup>a</sup>  | 7.07 $\pm$ 0.24 <sup>a</sup>   | 6.03 $\pm$ 0.19 <sup>a</sup> |
| AV 33%    | 8.30 $\pm$ 0.24 <sup>a</sup>  | 7.93 $\pm$ 0.14 <sup>a</sup>  | 7.14 $\pm$ 0.26 <sup>a</sup>  | 6.83 $\pm$ 0.31 <sup>a</sup>   | 6.53 $\pm$ 0.22 <sup>a</sup> |
| AV 50%    | 8.06 $\pm$ 0.18 <sup>a</sup>  | 7.55 $\pm$ 0.16 <sup>a</sup>  | 6.60 $\pm$ 0.35 <sup>a</sup>  | 7.00 $\pm$ 0.18 <sup>a</sup>   | 6.50 $\pm$ 0.13 <sup>a</sup> |
| CMC 1%    | 8.07 $\pm$ 0.22 <sup>a</sup>  | 7.86 $\pm$ 0.38 <sup>a</sup>  | 7.46 $\pm$ 0.19 <sup>a</sup>  | 7.04 $\pm$ 0.17 <sup>a</sup>   | 6.64 $\pm$ 0.18 <sup>a</sup> |
| CMC 1.5%  | 7.93 $\pm$ 0.33 <sup>a</sup>  | 7.43 $\pm$ 0.24 <sup>a</sup>  | 6.53 $\pm$ 0.24 <sup>a</sup>  | 7.10 $\pm$ 0.14 <sup>a</sup>   | 6.80 $\pm$ 0.14 <sup>a</sup> |
| CMC 2%    | 8.10 $\pm$ 0.19 <sup>a</sup>  | 7.80 $\pm$ 0.21 <sup>a</sup>  | 6.96 $\pm$ 0.44 <sup>a</sup>  | 6.64 $\pm$ 0.25 <sup>a</sup>   | 6.17 $\pm$ 0.32 <sup>a</sup> |
| PE 1%     | 8.20 $\pm$ 0.28 <sup>a</sup>  | 7.92 $\pm$ 0.33 <sup>a</sup>  | 6.63 $\pm$ 0.15 <sup>a</sup>  | 6.50 $\pm$ 0.36 <sup>a</sup>   | 6.01 $\pm$ 0.20 <sup>a</sup> |
| PE 1.5%   | 9.16 $\pm$ 0.35 <sup>a</sup>  | 8.05 $\pm$ 0.54 <sup>a</sup>  | 6.67 $\pm$ 0.23 <sup>a</sup>  | 6.90 $\pm$ 0.12 <sup>a</sup>   | 6.63 $\pm$ 0.36 <sup>a</sup> |
| PE 2%     | 8.47 $\pm$ 0.41 <sup>a</sup>  | 8.32 $\pm$ 0.25 <sup>a</sup>  | 6.60 $\pm$ 0.46 <sup>a</sup>  | 6.63 $\pm$ 0.22 <sup>a</sup>   | 6.24 $\pm$ 0.15 <sup>a</sup> |
| LSD       | 1.23                          | 0.87                          | 0.74                          | 0.65                           | 0.94                         |
| Treatment | TA (%)                        |                               |                               |                                |                              |
|           | Day 0                         | Day 10                        | Day 20                        | Day 30                         | Day 40                       |
| Control   | 1.27 $\pm$ 0.09 <sup>a</sup>  | 1.27 $\pm$ 0.07 <sup>b</sup>  | 1.40 $\pm$ 0.08 <sup>bc</sup> | 0.93 $\pm$ 0.06 <sup>bcd</sup> | 0.85 $\pm$ 0.05 <sup>a</sup> |
| AV 33%    | 1.52 $\pm$ 0.12 <sup>a</sup>  | 1.41 $\pm$ 0.09 <sup>b</sup>  | 1.58 $\pm$ 0.08 <sup>ab</sup> | 0.91 $\pm$ 0.08 <sup>bcd</sup> | 0.98 $\pm$ 0.07 <sup>a</sup> |
| AV 50%    | 1.44 $\pm$ 0.11 <sup>a</sup>  | 1.82 $\pm$ 0.13 <sup>a</sup>  | 1.63 $\pm$ 0.06 <sup>ab</sup> | 1.12 $\pm$ 0.05 <sup>a</sup>   | 1.00 $\pm$ 0.08 <sup>a</sup> |
| CMC 1%    | 1.36 $\pm$ 0.08 <sup>a</sup>  | 1.28 $\pm$ 0.08 <sup>b</sup>  | 1.61 $\pm$ 0.10 <sup>ab</sup> | 0.87 $\pm$ 0.04 <sup>cd</sup>  | 0.81 $\pm$ 0.06 <sup>a</sup> |
| CMC 1.5%  | 1.35 $\pm$ 0.07 <sup>a</sup>  | 1.17 $\pm$ 0.07 <sup>b</sup>  | 1.34 $\pm$ 0.09 <sup>bc</sup> | 1.00 $\pm$ 0.09 <sup>abc</sup> | 1.02 $\pm$ 0.08 <sup>a</sup> |
| CMC 2%    | 1.33 $\pm$ 0.06 <sup>a</sup>  | 1.12 $\pm$ 0.06 <sup>b</sup>  | 1.73 $\pm$ 0.12 <sup>a</sup>  | 0.88 $\pm$ 0.06 <sup>cd</sup>  | 0.94 $\pm$ 0.07 <sup>a</sup> |
| PE 1%     | 1.22 $\pm$ 0.08 <sup>a</sup>  | 1.16 $\pm$ 0.05 <sup>b</sup>  | 1.21 $\pm$ 0.07 <sup>c</sup>  | 0.82 $\pm$ 0.07 <sup>d</sup>   | 0.85 $\pm$ 0.10 <sup>a</sup> |
| PE 1.5%   | 1.72 $\pm$ 0.13 <sup>a</sup>  | 1.29 $\pm$ 0.10 <sup>b</sup>  | 1.10 $\pm$ 0.06 <sup>c</sup>  | 0.99 $\pm$ 0.07 <sup>abc</sup> | 0.98 $\pm$ 0.09 <sup>a</sup> |
| PE 2%     | 1.67 $\pm$ 0.10 <sup>a</sup>  | 1.29 $\pm$ 0.08 <sup>b</sup>  | 1.35 $\pm$ 0.11 <sup>bc</sup> | 1.03 $\pm$ 0.05 <sup>ab</sup>  | 0.93 $\pm$ 0.06 <sup>a</sup> |
| LSD       | 0.40                          | 0.36                          | 0.31                          | 0.13                           | 0.14                         |
| Treatment | pH                            |                               |                               |                                |                              |
|           | Day 0                         | Day 10                        | Day 20                        | Day 30                         | Day 40                       |
| Control   | 4.52 $\pm$ 0.12 <sup>a</sup>  | 4.28 $\pm$ 0.11 <sup>c</sup>  | 4.28 $\pm$ 0.10 <sup>bc</sup> | 4.25 $\pm$ 0.15 <sup>ab</sup>  | 4.35 $\pm$ 0.14 <sup>a</sup> |
| AV 33%    | 4.49 $\pm$ 0.11 <sup>a</sup>  | 4.13 $\pm$ 0.15 <sup>d</sup>  | 4.26 $\pm$ 0.14 <sup>c</sup>  | 4.29 $\pm$ 0.21 <sup>ab</sup>  | 4.31 $\pm$ 0.11 <sup>a</sup> |
| AV 50%    | 4.43 $\pm$ 0.15 <sup>a</sup>  | 4.13 $\pm$ 0.13 <sup>d</sup>  | 4.11 $\pm$ 0.11 <sup>d</sup>  | 4.14 $\pm$ 0.14 <sup>bc</sup>  | 4.14 $\pm$ 0.10 <sup>a</sup> |
| CMC 1%    | 4.59 $\pm$ 0.13 <sup>a</sup>  | 4.29 $\pm$ 0.16 <sup>c</sup>  | 4.41 $\pm$ 0.15 <sup>ab</sup> | 3.74 $\pm$ 0.17 <sup>d</sup>   | 4.45 $\pm$ 0.16 <sup>a</sup> |
| CMC 1.5%  | 4.37 $\pm$ 0.12 <sup>a</sup>  | 4.40 $\pm$ 0.10 <sup>ab</sup> | 4.10 $\pm$ 0.13 <sup>d</sup>  | 4.26 $\pm$ 0.16 <sup>ab</sup>  | 4.15 $\pm$ 0.15 <sup>a</sup> |
| CMC 2%    | 4.43 $\pm$ 0.14 <sup>a</sup>  | 4.29 $\pm$ 0.13 <sup>c</sup>  | 4.48 $\pm$ 0.18 <sup>a</sup>  | 4.35 $\pm$ 0.18 <sup>a</sup>   | 4.35 $\pm$ 0.14 <sup>a</sup> |
| PE 1%     | 4.59 $\pm$ 0.14 <sup>a</sup>  | 4.44 $\pm$ 0.18 <sup>a</sup>  | 4.29 $\pm$ 0.19 <sup>bc</sup> | 4.30 $\pm$ 0.13 <sup>ab</sup>  | 4.38 $\pm$ 0.17 <sup>a</sup> |
| PE 1.5%   | 4.61 $\pm$ 0.17 <sup>a</sup>  | 4.32 $\pm$ 0.13 <sup>bc</sup> | 4.31 $\pm$ 0.14 <sup>bc</sup> | 4.04 $\pm$ 0.10 <sup>c</sup>   | 4.32 $\pm$ 0.13 <sup>a</sup> |
| PE 2%     | 4.58 $\pm$ 0.11 <sup>a</sup>  | 4.26 $\pm$ 0.10 <sup>c</sup>  | 4.31 $\pm$ 0.11 <sup>bc</sup> | 3.63 $\pm$ 0.12 <sup>d</sup>   | 4.21 $\pm$ 0.10 <sup>a</sup> |
| LSD       | 0.16                          | 0.10                          | 0.12                          | 0.19                           | 0.11                         |

AV (Aloe vera); CMC (carboxymethyl cellulose); and PE (pectin).

†Means followed by different letters in the same column for the same evaluated parameter are significantly different ( $p \leq 0.05$ ) according to the LSD test.

## Vitamin C

As expected, vitamin C content in all the treatments decreased along time. The highest vitamin C (1018 mg 100 g<sup>-1</sup>) was obtained in coated fruit with pectin 2% at day 0, followed by pectin 1.5% (916.3 mg 100 g<sup>-1</sup>) and Aloe vera 50% (895.1 mg 100 g<sup>-1</sup>) (Table 2). However, no significant differences were found in vitamin C between samples at day 10. At day 20 and 30 of storage, significant differences were found in vitamin C between treatments. At day 20 the highest vitamin C (721.0 mg 100 g<sup>-1</sup>) was observed in coated jujube fruits with pectin 1%, while at day 30 of storage, the higher vitamin C was found in control and CMC 1%. At day 40 of storage, no significant changes were detected among all treatments. Overall, CMC and PE were better treatments than Aloe vera in retention of ascorbic acid (AA). It has also been reported that CMC coating was effective in reducing the ascorbic acid loss in apples (Saba & Sogvar, 2016) and cucumber (Oluwaseun et al., 2013) during storage. Likely, the reduction of AA loss in treated jujube fruit may be attributed to low oxygen permeability of edible coatings used as reported by previous studies of CMC (Freire et al., 2005) and Aloe vera coatings (Hassanpour, 2015).

**Table 2.** Firmness, weight loss and vitamin C of uncoated (control) and coated jujube fruit with different concentrations of aloe vera (AV), carboxymethyl cellulose (CMC) and pectin (PE) during 40 days of storage at  $4 \pm 1$  °C

| Treatment | Firmness (N)                        |                      |                         |                         |                      |
|-----------|-------------------------------------|----------------------|-------------------------|-------------------------|----------------------|
|           | Day 0                               | Day 10               | Day 20                  | Day 30                  | Day 40               |
| Control   | $0.96 \pm 0.05^{a†}$                | $1.19 \pm 0.07^{bc}$ | $1.15 \pm 0.08^{ab}$    | $0.75 \pm 0.07^a$       | $0.48 \pm 0.06^a$    |
| AV 33%    | $0.99 \pm 0.08^a$                   | $1.26 \pm 0.09^{bc}$ | $0.90 \pm 0.07^{bcd}$   | $0.67 \pm 0.04^{abc}$   | $0.51 \pm 0.04^a$    |
| AV 50%    | $1.09 \pm 0.06^a$                   | $1.57 \pm 0.11^a$    | $1.08 \pm 0.06^{abc}$   | $0.56 \pm 0.04^{bcde}$  | $0.46 \pm 0.05^a$    |
| CMC 1%    | $1.06 \pm 0.06^a$                   | $1.23 \pm 0.08^{bc}$ | $0.88 \pm 0.05^{bcd}$   | $0.73 \pm 0.06^{ab}$    | $0.51 \pm 0.05^a$    |
| CMC 1.5%  | $1.01 \pm 0.09^a$                   | $1.20 \pm 0.09^{bc}$ | $1.27 \pm 0.09^a$       | $0.53 \pm 0.05^{cde}$   | $0.50 \pm 0.04^a$    |
| CMC 2%    | $1.09 \pm 0.04^a$                   | $1.12 \pm 0.07^{bc}$ | $0.63 \pm 0.05^d$       | $0.42 \pm 0.04^e$       | $0.40 \pm 0.03^{ab}$ |
| PE 1%     | $1.06 \pm 0.03^a$                   | $1.31 \pm 0.06^b$    | $1.16 \pm 0.07^{ab}$    | $0.59 \pm 0.05^{abcde}$ | $0.45 \pm 0.04^{ab}$ |
| PE 1.5%   | $1.01 \pm 0.07^a$                   | $1.05 \pm 0.09^c$    | $1.12 \pm 0.07^{abc}$   | $0.44 \pm 0.04^{de}$    | $0.43 \pm 0.05^{ab}$ |
| PE 2%     | $1.21 \pm 0.05^a$                   | $1.09 \pm 0.07^{bc}$ | $0.79 \pm 0.05^{cd}$    | $0.61 \pm 0.07^{abcd}$  | $0.45 \pm 0.04^{ab}$ |
| LSD       | 0.25                                | 0.23                 | 0.33                    | 0.17                    | 0.15                 |
| Treatment | Weight loss (%)                     |                      |                         |                         |                      |
|           | Day 0                               | Day 10               | Day 20                  | Day 30                  | Day 40               |
| Control   | 0                                   | $0.17 \pm 0.02^a$    | $0.58 \pm 0.04^a$       | $1.20 \pm 0.08^a$       | $2.08 \pm 0.12^b$    |
| AV 33%    | 0                                   | $0.24 \pm 0.02^a$    | $0.65 \pm 0.05^a$       | $1.73 \pm 0.05^a$       | $2.93 \pm 0.21^a$    |
| AV 50%    | 0                                   | $0.24 \pm 0.03^a$    | $0.75 \pm 0.05^a$       | $1.61 \pm 0.07^a$       | $2.29 \pm 0.15^b$    |
| CMC 1%    | 0                                   | $0.18 \pm 0.01^a$    | $0.54 \pm 0.04^a$       | $1.25 \pm 0.07^a$       | $1.96 \pm 0.13^b$    |
| CMC 1.5%  | 0                                   | $0.22 \pm 0.03^a$    | $0.70 \pm 0.06^a$       | $1.34 \pm 0.09^a$       | $1.88 \pm 0.19^b$    |
| CMC 2%    | 0                                   | $0.37 \pm 0.03^a$    | $0.91 \pm 0.07^a$       | $1.40 \pm 0.10^a$       | $2.17 \pm 0.16^b$    |
| PE 1%     | 0                                   | $0.33 \pm 0.02^a$    | $0.97 \pm 0.08^a$       | $1.50 \pm 0.11^a$       | $2.42 \pm 0.18^{ab}$ |
| PE 1.5%   | 0                                   | $0.35 \pm 0.04^a$    | $0.80 \pm 0.06^a$       | $1.75 \pm 0.13^a$       | $2.95 \pm 0.20^a$    |
| PE 2%     | 0                                   | $0.23 \pm 0.02^a$    | $0.76 \pm 0.05^a$       | $1.52 \pm 0.09^a$       | $2.17 \pm 0.16^b$    |
| LSD       | -                                   | 0.16                 | 0.43                    | 0.48                    | 0.56                 |
| Treatment | Vitamin C (mg 100 g <sup>-1</sup> ) |                      |                         |                         |                      |
|           | Day 0                               | Day 10               | Day 20                  | Day 30                  | Day 40               |
| Control   | $820.66 \pm 8.72^{bc}$              | $669.00 \pm 7.54^a$  | $638.00 \pm 6.40^{abc}$ | $682.00 \pm 7.22^a$     | $242.00 \pm 3.30^a$  |
| AV 33%    | $658.20 \pm 10.42^d$                | $746.86 \pm 7.70^a$  | $563.20 \pm 5.12^c$     | $433.76 \pm 3.42^{bc}$  | $182.66 \pm 3.14^a$  |
| AV 50%    | $895.10 \pm 9.33^{abc}$             | $741.33 \pm 6.96^a$  | $624.80 \pm 7.02^{abc}$ | $395.03 \pm 4.11^c$     | $198.64 \pm 3.22^a$  |
| CMC 1%    | $776.56 \pm 8.22^{bcd}$             | $807.80 \pm 7.22^a$  | $619.60 \pm 7.13^{abc}$ | $681.67 \pm 6.33^a$     | $284.32 \pm 2.86^a$  |
| CMC 1.5%  | $739.20 \pm 7.57^{cd}$              | $712.67 \pm 6.43^a$  | $566.56 \pm 6.18^c$     | $542.23 \pm 4.50^{abc}$ | $247.86 \pm 3.44^a$  |
| CMC 2%    | $848.53 \pm 8.82^{bc}$              | $722.64 \pm 7.66^a$  | $535.60 \pm 5.95^c$     | $426.00 \pm 5.61^c$     | $216.86 \pm 3.30^a$  |
| PE 1%     | $760.00 \pm 6.95^{bcd}$             | $750.00 \pm 8.80^a$  | $721.00 \pm 7.44^a$     | $627.00 \pm 6.10^{ab}$  | $289.67 \pm 3.25^a$  |
| PE 1.5%   | $916.33 \pm 10.67^{ab}$             | $808.34 \pm 7.45^a$  | $596.00 \pm 5.30^{bc}$  | $460.02 \pm 3.87^{bc}$  | $239.64 \pm 2.85^a$  |
| PE 2%     | $1018.00 \pm 13.84^a$               | $810.66 \pm 7.31^a$  | $681.33 \pm 6.80^{ab}$  | $556.33 \pm 4.75^{abc}$ | $317.65 \pm 3.78^a$  |
| LSD       | 159.88                              | 151.59               | 102.64                  | 194.51                  | 140.58               |

AV (Aloe vera); CMC (carboxymethyl cellulose); and PE (pectin).

†Means followed by different letters in the same column for the same evaluated parameter are significantly different ( $p \leq 0.05$ ) according to the LSD test.

### Antioxidant activity

At the beginning of the experiment (day 0), the antioxidant activity was high, while there were no significant differences in all the treatments (Table 3). This trend remained unchanged as after 40 days of storage no significant changes were observed between the treatments. Although there was a decrease in antioxidant activity of coated and uncoated control fruits in all treatments at day 40 compared to day 0. It has been reported that fruit coating was effective to maintain antioxidant activity in either whole fruit or fresh cuts (Ali et al., 2013). Aloe vera coated fruit had greater antioxidant capacity than control in grapes (Serrano et al., 2006) and raspberry (Hassanpour, 2015). Hu et al. (2005) showed that Aloe vera likely increase the resistance of fruit tissues to decay. In the current study, neither Aloe vera nor CMC and pectin coatings maintain antioxidant activity. This is in agreement with the findings of Sogvar et al. (2016) in strawberry and in contrary to Saba and Sogvar (2016) study in apple who mention CMC treatment retained antioxidant capacity as the first day of storage. The decline in antioxidant activity in samples in all treated and control jujube fruit might be due to senescence after 40 days of storage period.

## Decay

No decay symptoms were detected at day 0 in all treatments (Table 3). However, after 40 days of storage, decay was found in some of the coated and uncoated control fruits. The highest percentage of fruit decay (9.25%) was obtained in control, followed by pectin 2% (3.45%), CMC 2% (2.6%) pectin 1.5% (2.25%) and Aloe vera 33% (1.4%). Nevertheless, there were no significant differences in fruit decay among these coating treatments. Interestingly, after 40 days of storage no decay was found in coated fruits with Aloe vera 50%, CMC 1 and 1.5%, and pectin 1%.

After 11 days, decay in aloe vera treated kiwifruits slices stored at  $4 \pm 1$  °C was significantly lower than in control (Benítez et al., 2015). Similarly, in aloe vera coated sweet cherry (Martinez Romero et al., 2006) a reduction of mold and bacteria were observed after 16 days of cold storage compared to the control. Under refrigerated conditions after 45 days of storage, no decay was observed in coated plum fruits with CMC at 0.75 and 1.0% w/v, 1.5 kGy irradiation and the combination of CMC coating and irradiation compared to control (Hussain et al., 2015). Indian jujube fruits stored with control packing and without coating were decayed about 18% at the 45th day of cold storage, whereas the fruit coated with aloe-pectin had lower fruit decay on the 45th day of storage (Padmaja & Bosco, 2014). Previous scientific studies have shown the antifungal activities of aloe vera gel (Benítez, et al., 2015; Das et al., 2011) and therefore it could prevent the growth of the fungi.

## Overall acceptability

There were differences in sensory assessments among the fruits coated with Aloe vera, CMC, and pectin as shown in Table 3. At day 0 no significant differences were observed in all the treatments (Table 3). However, after 40 days of storage, coated fruits with CMC at all applied concentrations had the higher acceptability judged by panelists based on fruit taste, flesh color and texture, followed by Aloe vera 50%. Nevertheless, other coated and uncoated control jujube fruits get overall acceptability after 40 days of storage.

**Table 3.** Antioxidant activity, decay percentage and overall acceptability of uncoated (control) and coated jujube fruit with different concentrations of aloe vera (AV), carboxymethyl cellulose (CMC) and pectin (PE) at day 0 and after 40 days of storage at  $4 \pm 1$  °C

| Treatment | Antioxidant (%)                |                               | Decay percentage (%) |                              | Overall acceptability*      |                              |
|-----------|--------------------------------|-------------------------------|----------------------|------------------------------|-----------------------------|------------------------------|
|           | Day 0                          | Day 40                        | Day 0                | Day 40                       | Day 0                       | Day 40                       |
| Control   | 96.34 $\pm$ 0.63 <sup>a†</sup> | 64.63 $\pm$ 0.44 <sup>a</sup> | ND                   | 9.25 $\pm$ 0.35 <sup>a</sup> | 7.1 $\pm$ 0.45 <sup>a</sup> | 5.3 $\pm$ 0.28 <sup>c</sup>  |
| AV 33%    | 94.76 $\pm$ 0.83 <sup>a</sup>  | 76.78 $\pm$ 0.53 <sup>a</sup> | ND                   | 1.40 $\pm$ 0.11 <sup>b</sup> | 7.0 $\pm$ 0.39 <sup>a</sup> | 6.0 $\pm$ 0.29 <sup>b</sup>  |
| AV 50%    | 97.12 $\pm$ 0.57 <sup>a</sup>  | 74.83 $\pm$ 0.41 <sup>a</sup> | ND                   | ND                           | 6.9 $\pm$ 0.34 <sup>a</sup> | 6.4 $\pm$ 0.32 <sup>ab</sup> |
| CMC 1%    | 96.24 $\pm$ 0.74 <sup>a</sup>  | 70.97 $\pm$ 0.48 <sup>a</sup> | ND                   | ND                           | 7.2 $\pm$ 0.35 <sup>a</sup> | 6.8 $\pm$ 0.30 <sup>a</sup>  |
| CMC 1.5%  | 94.49 $\pm$ 0.58 <sup>a</sup>  | 75.52 $\pm$ 0.38 <sup>a</sup> | ND                   | ND                           | 7.3 $\pm$ 0.41 <sup>a</sup> | 7.0 $\pm$ 0.35 <sup>a</sup>  |
| CMC 2%    | 94.58 $\pm$ 0.66 <sup>a</sup>  | 67.72 $\pm$ 0.55 <sup>a</sup> | ND                   | 2.60 $\pm$ 0.12 <sup>b</sup> | 6.9 $\pm$ 0.25 <sup>a</sup> | 6.8 $\pm$ 0.27 <sup>a</sup>  |
| PE 1%     | 97.81 $\pm$ 0.72 <sup>a</sup>  | 75.36 $\pm$ 0.59 <sup>a</sup> | ND                   | ND                           | 6.8 $\pm$ 0.28 <sup>a</sup> | 6.0 $\pm$ 0.33 <sup>b</sup>  |
| PE 1.5%   | 95.15 $\pm$ 0.54 <sup>a</sup>  | 79.34 $\pm$ 0.60 <sup>a</sup> | ND                   | 2.25 $\pm$ 0.14 <sup>b</sup> | 7.0 $\pm$ 0.30 <sup>a</sup> | 5.3 $\pm$ 0.19 <sup>c</sup>  |
| PE 2%     | 95.03 $\pm$ 0.80 <sup>a</sup>  | 73.81 $\pm$ 0.57 <sup>a</sup> | ND                   | 3.45 $\pm$ 0.21 <sup>b</sup> | 7.0 $\pm$ 0.32 <sup>a</sup> | 5.2 $\pm$ 0.22 <sup>c</sup>  |
| LSD       | 2.92                           | 10.72                         | 2.33                 | 3.58                         | 0.59                        | 0.48                         |

AV (Aloe vera); CMC (carboxymethyl cellulose); and PE (pectin); ND = no decay.

<sup>†</sup>Means followed by different letters in the same column are significantly different ( $p \leq 0.05$ ) according to the LSD test.

\*Scores of 5 and above were considered acceptable

**Table 4.** Lightness ( $L^*$ ),  $a^*$  and  $b^*$  values of uncoated (control) and coated jujube fruit with different concentrations of aloe vera (AV), carboxymethyl cellulose (CMC) and pectin (PE) at day 0 and after 40 days of storage at  $4 \pm 1$  °C

| Treatment | Color parameters               |                               |                               |                               |                               |                               |
|-----------|--------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
|           | $L^*$                          |                               | $a^*$                         |                               | $b^*$                         |                               |
|           | Day 0                          | Day 40                        | Day 0                         | Day 40                        | Day 0                         | Day 40                        |
| Control   | 61.59 $\pm$ 0.58 <sup>a†</sup> | 35.05 $\pm$ 0.24 <sup>c</sup> | 27.29 $\pm$ 0.18 <sup>a</sup> | 48.58 $\pm$ 0.68 <sup>b</sup> | 31.24 $\pm$ 0.14 <sup>a</sup> | 59.36 $\pm$ 0.19 <sup>a</sup> |
| AV 33%    | 62.69 $\pm$ 0.47 <sup>a</sup>  | 43.30 $\pm$ 0.31 <sup>a</sup> | 26.29 $\pm$ 0.15 <sup>a</sup> | 49.07 $\pm$ 0.51 <sup>b</sup> | 31.25 $\pm$ 0.20 <sup>a</sup> | 48.43 $\pm$ 0.21 <sup>b</sup> |
| AV 50%    | 61.69 $\pm$ 0.38 <sup>a</sup>  | 43.12 $\pm$ 0.27 <sup>a</sup> | 27.29 $\pm$ 0.16 <sup>a</sup> | 54.66 $\pm$ 0.44 <sup>a</sup> | 31.24 $\pm$ 0.18 <sup>a</sup> | 43.38 $\pm$ 0.24 <sup>b</sup> |
| CMC 1%    | 62.49 $\pm$ 0.74 <sup>a</sup>  | 40.70 $\pm$ 0.41 <sup>b</sup> | 27.30 $\pm$ 0.17 <sup>a</sup> | 49.64 $\pm$ 0.41 <sup>b</sup> | 31.22 $\pm$ 0.23 <sup>a</sup> | 52.06 $\pm$ 0.18 <sup>a</sup> |
| CMC 1.5%  | 61.99 $\pm$ 0.54 <sup>a</sup>  | 38.06 $\pm$ 0.25 <sup>b</sup> | 27.28 $\pm$ 0.21 <sup>a</sup> | 51.03 $\pm$ 0.60 <sup>a</sup> | 31.23 $\pm$ 0.16 <sup>a</sup> | 54.14 $\pm$ 0.31 <sup>a</sup> |
| CMC 2%    | 61.49 $\pm$ 0.81 <sup>a</sup>  | 40.73 $\pm$ 0.20 <sup>b</sup> | 28.29 $\pm$ 0.20 <sup>a</sup> | 52.27 $\pm$ 0.52 <sup>a</sup> | 31.25 $\pm$ 0.21 <sup>a</sup> | 46.73 $\pm$ 0.35 <sup>b</sup> |
| PE 1%     | 62.68 $\pm$ 0.66 <sup>a</sup>  | 37.47 $\pm$ 0.19 <sup>b</sup> | 26.30 $\pm$ 0.15 <sup>a</sup> | 49.91 $\pm$ 0.43 <sup>b</sup> | 31.20 $\pm$ 0.17 <sup>a</sup> | 56.27 $\pm$ 0.26 <sup>a</sup> |
| PE 1.5%   | 61.70 $\pm$ 0.71 <sup>a</sup>  | 37.92 $\pm$ 0.18 <sup>b</sup> | 28.28 $\pm$ 0.18 <sup>a</sup> | 45.60 $\pm$ 0.42 <sup>b</sup> | 31.26 $\pm$ 0.22 <sup>a</sup> | 48.53 $\pm$ 0.27 <sup>b</sup> |
| PE 2%     | 61.69 $\pm$ 0.54 <sup>a</sup>  | 38.78 $\pm$ 0.23 <sup>b</sup> | 27.30 $\pm$ 0.16 <sup>a</sup> | 49.35 $\pm$ 0.38 <sup>b</sup> | 31.25 $\pm$ 0.14 <sup>a</sup> | 48.80 $\pm$ 0.39 <sup>b</sup> |
| LSD       | 1.13                           | 2.43                          | 1.52                          | 3.48                          | 0.24                          | 5.14                          |

AV (Aloe vera); CMC (carboxymethyl cellulose); and PE (pectin).

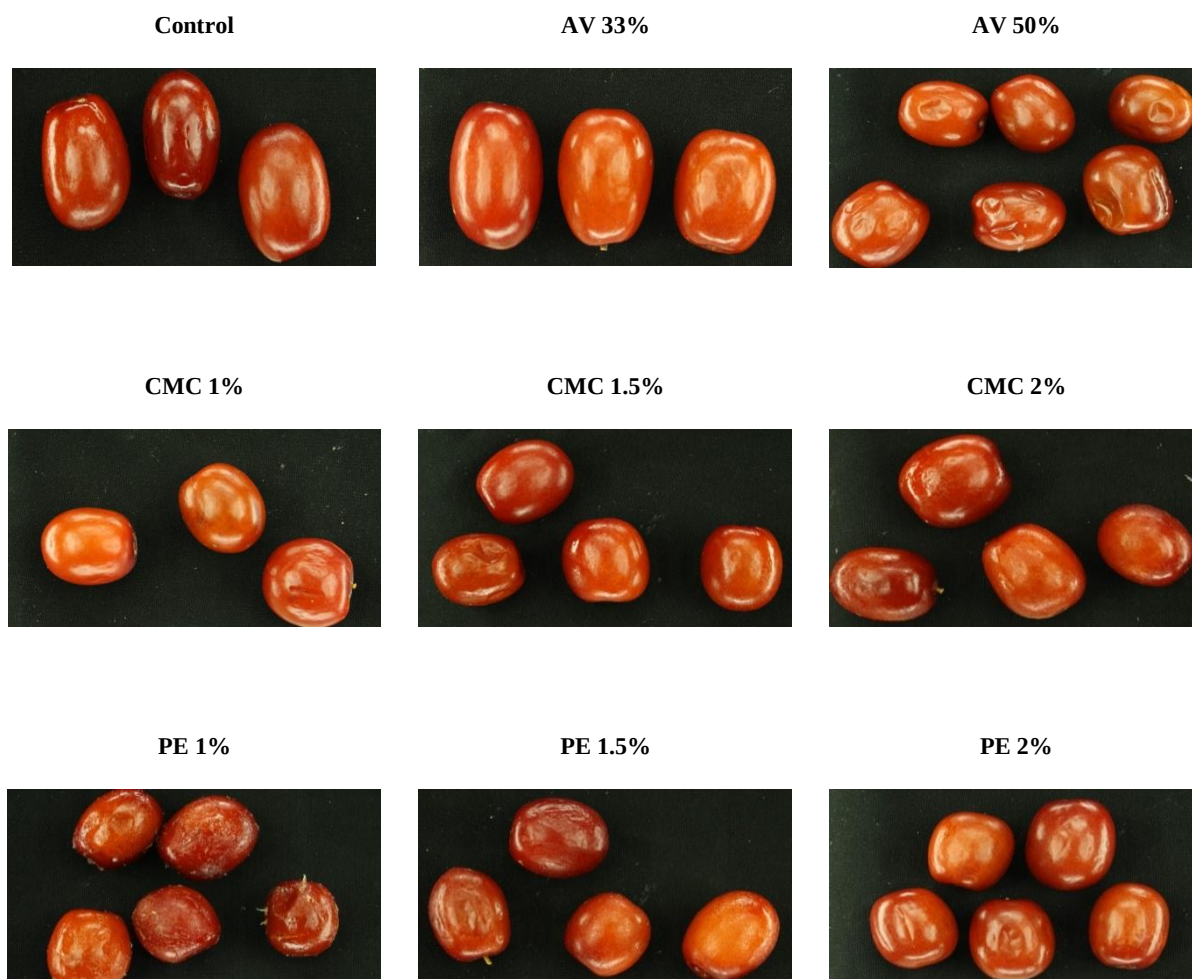
†Means followed by different letters in the same column for the same evaluated parameter are significantly different ( $p \leq 0.05$ ) according to the LSD test.

Plum fruits coated with CMC and irradiations alone or in combination had acceptable quality at day 35 of cold storage (Hussain et al., 2015). After 16 days of cold storage, sweet cherry fruits treated with Aloe vera gel had similar freshness as harvested fruit (Martínez-Romero et al., 2006). Valverde et al. (2005) also stated that Aloe vera coated grapes get a higher score by panel than control for juiciness and freshness. Guerreiro et al. (2015) mentioned that raspberry fruits treated with pectin after 14 days of storage were not acceptable likely due to high weight loss recorded during storage time. Similarly, in current study pectin coated fruit had lower acceptability than CMC and Aloe vera treatments at the end of storage time. The appearance quality of uncoated control and coated fresh jujube fruits with different concentrations of Aloe vera, CMC and pectin are shown in Figure 1.

### Color parameters

The results showed no significant difference in the  $L^*$ ,  $a^*$  and  $b^*$  values of jujube fruits treated with different coating treatments at day 0 of storage (Table 4). However, after 40 days of refrigerated storage, significant differences were observed among the coating treatments in  $L^*$ ,  $a^*$  and  $b^*$  parameters. The highest lightness ( $L$ ) values (43) was obtained in AV coated fruit and the lowest (35) in the untreated control. Lightness was better maintained in AV coated fruit with less decrease than other treatments, which means AV coating could prevent the fresh jujube fruit from becoming darker compared to control. This is in agreement with the findings of Valverde et al. (2005) in coated grapes with AV gel. There were also significant differences between AV and CMC or pectin treatments. The  $a^*$  value was significantly increased for AV 50%, CMC 1.5 and 2% compared to the control and other coating treatments. The peel color was turning to reddish brown and was more in control than coated fruit with AV 50%, CMC 1.5 and 2%. Padmaja and Bosco (2014) also reported that AV treatment slows down the color change of coated jujube towards red color than uncoated control. After 40 days of storage, the  $b$  value was greater in some of the treatments and uncoated control. The highest  $b$  values were found in control (59) and coated jujube fruits with CMC 1% (52), CMC 1.5% (54) and pectin 1% (56). Fruit color is one of the important quality factors of fruit ripeness and is used by consumers to make conclusions on the ripeness of the fresh jujube fruit. Chinese jujubes are harvested in fully red color and behave as a non-climacteric fruit and thus, only small changes of color attributes are expected.

**Fig. 1.** Uncoated (control) and coated fresh jujube fruits with different concentrations of aloe vera (AV), carboxymethyl cellulose (CMC) and pectin (PE) after 40 days of storage at  $4 \pm 1$  °C



AV (Aloe vera); CMC (carboxymethyl cellulose); and PE (pectin).

## CONCLUSION

The results of this study indicate that the quality of Chinese jujube fruit is influenced by the application of edible coatings (AV gel, CMC, and pectin). Regardless of storage time, the coatings did not drastically affect the pH, TSS, weight loss, ascorbic acid and antioxidant activity. However, the edible coatings caused a significantly higher TA in jujube fruits (better flavor), reduced microbial growth, and preserved sensory characteristics as well as increased appearance quality of fruits. In general, among applied treatments, AV gel and CMC coatings at lower concentrations (1 and 1.5%) better improved the overall acceptability of jujube fruits compared to pectin treatment and untreated control.

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## تأثیر پوشش‌های خوراکی بر کیفیت پس از برداشت میوه عنب چینی در طی نگهداری در یخچال

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چکیده:

میوه عنب به واسطه طبیعت ذاتی فاسد شدنی، ماندگاری کوتاهی دارد. حفظ کیفیت عنب یک چالش بزرگ می‌باشد. استفاده از پوشش‌های خوراکی قرن‌هاست که در صنایع غذایی به عنوان یک روش موثر برای نگهداری تولیدات غذایی، بهبود ماندگاری و جلوگیری از افت سفتی و رطوبت در میوه‌های تازه کاربرد دارد. با وجود این، اطلاعات اندکی در خصوص تأثیر پوشش‌های خوراکی بر میوه عنب چینی وجود دارد. از این‌رو تأثیر پوشش‌های خوراکی مختلف شامل ژل آلون‌ه‌ورا (۳۳ و ۵۰ درصد حجمی/حجمی)، کربوکسی متیل سلولز و پکتین (۱، ۱/۵ و ۲ درصد وزنی/حجمی) بر کیفیت عنب تازه در طی ۴۰ روز نگهداری در یخچال در دمای ۴ درجه سانتی‌گراد مورد مطالعه قرار گرفت. نتایج نشان داد که افت وزن تقریباً تا ۳۰ درصد در عنب‌های پوشش‌دار شده با آلون‌ه‌ورا ۳۳ درصد یا پکتین ۱/۵ درصد در مقایسه با شاهد بدون پوشش پس از ۴۰ روز کاهش یافت. میوه‌های بدون پوشش فساد معنی‌دار بیشتری پس از ۴۰ روز نگهداری نسبت به سایر تیمارهای پوششی نشان دادند. نتایج همچنین نشان داد که پوشش‌دار کردن با آلون‌ه‌ورا ۵۰ درصد، کربوکسی متیل سلولز ۱ و ۲ درصد موجب افزایش معنی‌داری در اسیدیته قابل تیتر میوه عنب شد، و قابلیت حسی چشایی و همچنین کیفیت ظاهری را در مقایسه با میوه‌های بدون پوشش حفظ کرد. به‌طور کلی، پوشش‌دار کردن میوه با آلون‌ه‌ورا در هر دو غلظت و کربوکسی متیل سلولز ۱ و ۱/۵ درصد پس از ۴۰ روز نگهداری در یخچال حفظ کیفیت بهتر میوه عنب را در مقایسه با شاهد داشت.

کلمات کلیدی: آلون‌ه‌ورا، کربوکسی متیل سلولز، میوه تازه، پکتین، عنب چینی