Egypt. J. Food Sci. **Vol. 46,** 113- 11 (2018)

The Use of Edible Coatings to Preserve Quality of Fresh Cut Kiwi Fruits (Ready to Eat)

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THE AIM of the current study was to evaluate the effect of gelatin and Aloe vera coating on physicochemical, microbial, and sensorial properties of fresh-cut kiwi fruits stored at 4±1°C for 12 days.The slices of kiwi fruit were covered with gelatin and/or Aleo vera gel whilet he uncoated samples were served as control.The kiwi fruit slices were packaged and cold stored. Quality attributes such as weight loss, firmness,total soluble solids,vitamin C, pH, titratable acidity, microbial load and sensory properties were evaluated during storage. Our results highlighted that an Aloe vera coating improved the quality of stored kiwi fruit slices. The best results obtained in the instrumental firmness and in the preference panel test were with the mixture ofgelatinandAleovera gel (5:100) and Aleo vera gel only. Significant differences in terms of quality parameters were observed between the control and coated fresh-cut kiwi fruits.The highest variation of quality parameters was observed in the control, while the lowest variations were noticed in coated slices with gelatin and Aleo vera gel mixture (5:100) and withAleo vera gel alone. The weight loss increased with storage time, but the coating treatment especially with gelatin and Aleo vera gel (5:100) had significant effect on decreasing weight loss. Also, the same samples had the best microbiological quality and were ranked the highest scores for sensory evaluation.

Keywords: Kiwi fruits, Edible coatings, Gelatin, Aloe vera gel

Introduction

The wide success of kiwi fruit (*Actinidia deliciosa*) is mainly due to the bright colour of the flesh that, together with its flavour and high nutraceutical valueVitamin C content which represents the most important fruit attributes. Indeed, kiwifruit slices are largely used in fruit salads or in confectionery where they are the only green-fleshed fruit used. However, peeling and slicing involved in minimal processing can cause physical damage and increase ethylene production and respiration of kiwi fruit (Agar et al.,1999). Furthermore, the disruption of the fruit cells caused by the cut, frees the cellular content and promotes the microbial development (Garcia and Barrett, 2002). Selling minimally processed fresh fruit requires a combination of appropriate strategies that extend shelf-life while maintaining fruit organoleptic properties. Early studies on kiwi fruit showed that one of the changes involved in tissue softening is the solubilization of pectic polymers from the cell wall (Arpaia et al., 1987 and Redgwell et al., 1990).Several preservation technologies including cold storage, chemical dipping, active atmosphere modification and edible coatings have been used to prolong the shelf-life and to retain the nutritional value of minimally processed kiwi fruit (Roller and Seedhar, 2002; Xu et al., 2003; Mastromatteo et al.,2011).

Edible coatings can be used as barriers to microbial agents while reducing the deleterious effects of minimal processing to fresh-cut fruit (Moreira et al., 2011 and Correa-Betanzoet al., 2013).The use of edible coatings is growing, due to their multiple uses for extending fruit shelf-life and also as carriers for several food additives (Mastromatteo et al., 2011).Among the natural polymers able to form edible films, starch and gelatin are potential sources. Gelatin differs from other hydrocolloids as a fully digestible protein, containing nearly all the essential amino acids, except tryptophan (Duconseille et al., 2015).

Aloe vera gel has been used as an edible coating for some raw products such as nectarines (Ahmed et al., 2009). Aloe vera gel isa polysaccharide matrix rich in active compound that have been used for centuries due to its medicinal and the rapeutic properties (Ni et al., 2004). Aloe vera and its physiologically active substances have been the topic of several reviews and studies (Choi & Chung, 2003; Eshun & He, 2004; Rodriguez et al., 2010). Typically, the Aloe vera concentrations mentioned in these articles ranged between 50 and100%, although much lower was applied for apples (0–10%). The results of some studies indicated that Aloe vera reduced respiration rate and ethylene production, weight loss and softening. Chauhan et al. (2011) showed that Aloe gel coating alone or in combination with shellac, preserved physicochemical parameters such as colour and firmness in appleslices. However, effectiveness of Aloe vera has seldom been tested in other minimally processed products. Edible Aloe vera gel coating seems to have a beneficial effect on the retention of quality in minimally processed kiwi fruit slices by retarding the yellowing process, reducing microbial growth and improving total pectin and texture retention (Benitez et al., 2013).Aloe vera gel and gelatin have been used as edible coatings in fruit storage technology (Dang et al., 2008; Andrade et al., 2014).Application was done on mangoes (Dang et al., 2008), apples (Song et al., 2013), papayas (Marpudi, et al., 2011), table grapes (Valverde et al., 2005), and fresh-cut kiwi fruit (Benitez et al., 2013 and 2015). Several preservation technologies, comprising the combination of cold storage with calcium salt dips (Antunes et al., 2007).

Therefore, the current research was established to investigate the effect of edible coating with gelatin, Aloe vera gel and their mixtures on the physicochemical parameters, microbial load and sensory quality of minimally processed kiwi fruit during storage.

Materials and Methods

Minimal processing of fruit material

Kiwi fruit 'Hayward' was obtained from the local market and selected based on homogeneity in size,shape and apparent ripeness. The kiwi fruit was stored at 4±1°C and 70-75% RH until used. The kiwi fruit was sanitized with chlorinated water (200 mg/L) for 5 min and rinsed with tap water and drained for 5 min, hand-peeled and then cut into 4–5 slices of 1cm thickness. The slices were dipped in 2% (w/v) calcium chloride solution as solidifying agent, then drained and randomly divided into 4 groups, after that the prepared slices were immersed into different coatings for 3 min and dried for 2-3 min which corresponded to 4 coating treatments, and 1 water dipped as a control.

Preparation of edible coatings

Preparation of gelatin solution

The filmogenic gelatin solution was prepared by the hydration of 5 g of gelatin in 100 mL of distilled water for 1 hr at room temperature.

Aloe vera gel extraction. The collected mature leaves of Aloe vera plant were prepared by cutting-off the base and edges of leaves, subsequently clean up with distilled water and 2% sodium hypochlorite and chopped off into pieces, which were soaked overnight in water. On the next day morning, their green-coloured outer cortex was removed so as to obtain the colourless hydro parenchyma and they were ground using a mixer grinder. The resulting mixture was filtered through a tea strainer (1 mm^2) to remove fibers, and the gel matrix was collected, pasteurized at 70°C for 45 min and allowed to cool at room temperature. Finally,the viscosity and adherence of the A. vera gel was improved by adding 1.5% glycerol and the fruit was cold stored in an air tight glass reagent bottles (Kuwar et al., 2015).

Preparation and application of the edible coatings

Four coating treatments as well as the control were carried out as follows:

TABLE 1. Details of treatments used in the current study.

Treatments	Details of the treatments
A	Gelatin powder (5g) was dissolved in 100 ml distilled water.
B	Gelatin powder (5g) was mixed with Aloe vera gel (50 ml) and with 50 ml distilled water.
C	Gelatin powder (5g) was mixed with Aloe vera gel (100 ml)
D	Aloe vera gel only was used.
E(Control)	Distilled water

In the coating treatments, the prepared mixtures were heated to 70 °C for 10 min with stirring, Preparation of gelatin coating was done according to the method of Fakhouri et al. (2015). All samples were air dried at ambient temperature for 15 min before packaging. Samples were packed in polyethylene terephthalate (PET) and stored at 4 ± 1°C and 70-75% RH for 12 days for subsequent analysis. The experiment was conducted in duplicate and three samples for each treatment were randomly selected for analysis. The samples were analyzed at zero,2, 4, 6, 8, 10, 12 days during storage.

Physical and chemical analyses

Weight loss determination

This was calculated as loss in weight of the kiwi slices in each container during storage by the following formula:

$$\text{weight loss\%} = \frac{\text{Initial weight} - \text{weight in the specific time of storage}}{\text{initial weight}} \times 100.$$

Total soluble solid (TSS)

It was determined in the juice by the refractometric method at room temperature using apolish manual refractometr (R R 12, Nr 05116, 0-35% at 20 C) according to the method given in the A. O. A. C., (2000).

Firmness

It was measured using a hand dynamometer model FDP 1000 with a thump (2 mm) ingf (gram- force). The data were transformed into Newton units using standard factor (1 gram- force =0.00980665 Newton).

Determination of pH values

pH meter was used for pH measurement of the extracted juices as described in A.O.A.C. (2000).

Total titratable acidity (TTA)

It was determined in the extracted juices as described in A.O.A.C. (2000).

Ascorbicacid (V.C)

It was determined using 2,6 dichlorophenolindophenol titrimetic method follwing A.O.A.C., (2000). The results were expressed in milligrams ascorbic acid per 100 ml of fruit juice.

Microbiological evaluation

The microbiological analyses of kiwi slices were carried out including total bacterial count (TC) and count of yeasts and moluds (Y&M) (Benitez et al., 2013). Results were expressed as log CFU/g.

Sensory evaluation

It was carried out by eight trained panelists as described by Benitez et al. (2013).

Statistical analysis

This was carried out according to SAS (2010).

Results and Discussion

Visually the coatings adhered uniformly to the kiwi slices, presenting a natural bright, without rupture zones. Moreover, the use of coating kept the natural flavour of kiwi slices. The appearance of fruits can be seen in Fig. 1.

Weight loss (WL)

All samples demonstrated a gradual loss in weight during storage (Table 2). The weight loss in uncoated kiwi slices was significantly greater than those of coated samples during regular storage period.The weight loss increased with advancing storage time and the highest rate was observed in the control samples (3.92%) after 4 days of storage.The lowest rates (1.02 and 1.30%) were observed in treatments C and D, respectively after 12 days of storage (Table 2). Consequently, the weight loss of their coated samples was significantly lower than the other samples ($P \leq 0.05$).In this regard, the Aloe vera coating and gelatin was more effective. Similar results were obtained by Radi et al. (2017). It was reported that Aloe vera gel reduced the respiration rate, ethylene production, weight loss, and therefore the softening of fresh-cut fruit textures (Benitez et al., 2013). Gelatin coatings showed good barrier characteristics against oxygen and aroma transfer at low and intermediate relative humidity. However, they had poor barrier properties against water vapor transfer due to their hydrophilic nature (Andrade et al., 2014). Therefore, to modify the poor water vapor barrier properties of this protein film, a combined coating of gelatin with other substances may be used. However, the weight loss is mainly associated with moisture evaporation through the surface of fruit slices (Olivas et al., 2007). The rate of water loss depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere and the storage temperature. Thus, the slicing of fruits makes them susceptible to rapid water loss, resulting in shriveling;but edible coatings are supposed to control the water loss and therefore delay weight loss in fresh-cut fruits (Perez-Gago et al., 2006 and Dhall, 2013).

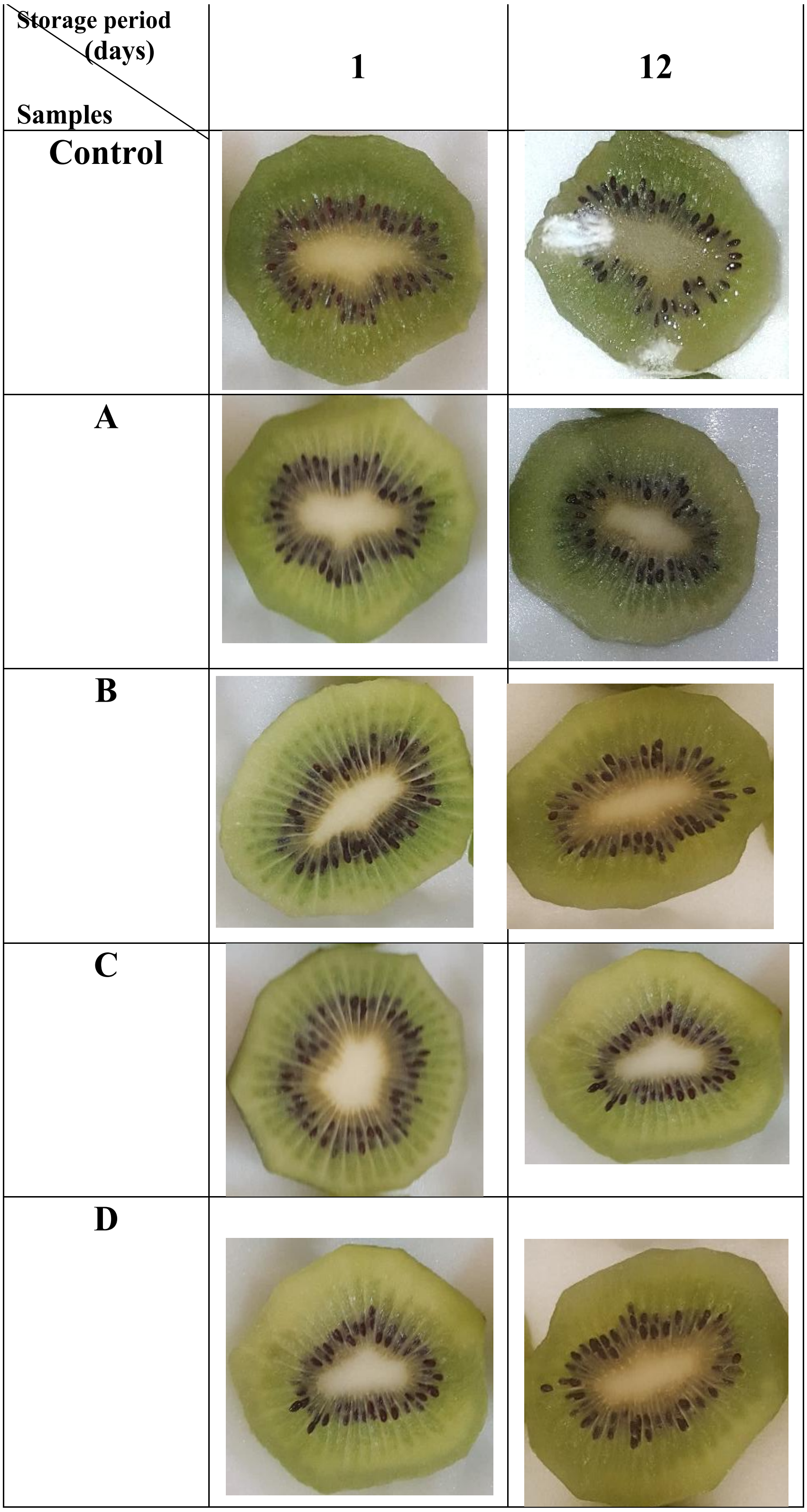

Fig.1. Images of kiwi fruits slices (coated and control) during storage.

*Treatments A: (5% gelatin powder in water),B: (5g gelatin powder in 50 ml Aleo vera gel + 50 ml water),C: (5g gelatin powder in100 ml Aleo vera gel), D: Aleo vera gel only,

TABLE 2. Effect of coating types on weight loss (%) of minimally processed kiwi fruit slices during cold storage.

Types*	Storage periods(day)						
	0	2	4	6	8	10	12
A	0.00	0.43^{Be}	0.73^{Bd}	0.87^{Acd}	0.97^{Ac}	1.52^{Ab}	2.61^{Aa}
B	0.00	0.43^{Bf}	0.64^{Ce}	0.74^{Bd}	0.84^{Bc}	0.99^{Bb}	1.46^{Ba}
C	0.00	0.41^{Cf}	0.56^{Ce}	0.58^{Dd}	0.67^{Cc}	0.78^{Cb}	1.02^{Da}
D	0.00	0.43^{Bf}	0.65^{De}	0.71^{Cd}	0.83^{Bc}	0.99^{Bb}	1.30^{Ca}
E	0.00	1.53^{Ab}	3.92^{Aa}	ND	ND	ND	ND*

*Treatments A: (5% gelatin powder in water),B: (5g gelatin powder in 50 ml Aleo vera gel + 50 ml water),C: (5g gelatin powder in100 ml Aleo vera gel), D: Aleo vera gel only,E:uncoated samples (control) -ND:Not determined because of spoilage.

- Means with different letters in the same column (capital letters) or in the same row (small letters) differed significantly ($p \leq 0.05$).

Total soluble solids (TSS)

The TSS of control and coated samples significantly increased with storage time. In this regard, there was asignificant difference between control and coated samples, as coated samples experienced a slight increase in TSS when compared to the control. The highest increase of TSS was observed in the control (12.0) after 4 days of cold storage (Table 3), while the lowest increase was observed in treatments C, D and B while no significant differences between all of them.This finding was similar to the results of Ahmed et al. (2009) and Marpudi et al. (2011) who reported that TSS increased with advancing storage time in nectarines and papaya. Conversely, Song et al. (2013) declared that the storage period did not affect the TSS of gel-coated apple slices. This result was also given by Bett et al. (2001). In general, it seems that TSS content tends to increase over the storage period as a consequence of ripening process (Albanese et al., 2007; Benitez et al., 2013). The reduction of respiration rate has been observed in kiwi fruit coated with Aloe vera gel (Benitez et al., 2013).

Firmness

The firmness of the kiwi fruit slices declined after 12 days of cold storage (Table 4). Firmness decreased slowly at firstand more faster with the twelve days of storage in coated slices. The marked decrease in firmness, possibly due to minimal processing operations, which was then maintained until the end of the experiment. The kiwi fruit slices treated with C coatings were significantly firmer ($p \leq 0.05$) than all treated slices (2.70 Nmm^{-1}) after 12 days of storage. However, control slices had the lowest value (0.87 Nmm^{-1}) after only 4 days of storage. These results are in agreement with Benitez et al. (2013) and Radi et al. (2017).

TABLE 3. Effect of coating types on TSS (°BX) of minimally processed kiwi fruit slices during cold storage.

Types*	Storage periods (day)						
	0	2	4	6	8	10	12
A	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.5^{Aa}	11.5^{Aa}	12.0^{Ba}
B	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.5^{Aa}	11.5^{Aa}	11.5^{Aa}
C	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.5^{Aa}	11.5^{Aa}	11.5^{Aa}
D	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.0^{Ab}	11.5^{Aa}	11.5^{Aa}	11.5^{Aa}
E	11.0^{Ac}	11.5^{Bb}	12.0^{Ba}	ND	ND	ND	ND*

- See legend of Table 2 for details.

TABLE 4. Effect of coating types on firmness (Nmm^{-1}) of minimally processed kiwi fruit slices cold of storage.

Types*	Storage periods(day)						
	0	2	4	6	8	10	12
A	3.43^{ABa}	3.40^{Ab}	3.31^{Bc}	3.18^{Cd}	2.84^{Ce}	2.55^{Cf}	2.08^{Dg}
B	3.40^{Ca}	3.40^{Aa}	3.31^{Bb}	3.20^{Bc}	2.94^{Bd}	2.84^{Be}	2.30^{Cf}
C	3.43^{ABa}	3.41^{Ab}	3.34^{Ac}	3.26^{Ad}	3.04^{Ae}	2.89^{Af}	2.70^{Ag}
D	3.42^{BCa}	3.41^{Aa}	3.30^{Bb}	3.20^{Bc}	2.94^{Bd}	2.84^{Be}	2.32^{Bf}
E	3.44^{Aa}	2.01^{Bb}	0.87^{Cc}	ND	ND	ND	ND*

- See legend of Table 2 for details.

In general, softening occurs due to the process of deterioration of the cell structure, primarily by the hydrolysis of pectic polymers in the cell wall and middle lamella of fruit. Ripening involves the depolymerization or shortening of the chain length of pectin substances along with an increase in pectinesterase and polygalacturonase activities (Yaman and Bayoindirli, 2002).

pH

The pH was increased significantly in all treatments during storage. The lowest value of (3.70) was observed in stored coated sample with C coatings (Table 5). In contrast, the highest pH (3.73) was observed in samples coated with A coatings at 12 days of storage compared to uncoated samples (3.75) at 4 days of storage. pH values of A coated samples were higher than the other samples followed by B, D, C coated slices (Table 5). These results are in agreement with Bett et al. (2001) and Benitez et al.(2013).

Total titratable acidity (TTA)

The total titratable acidity (TTA) of the coated and uncoated samples (Table 6) significantly decreased with different rates during the storage period ($P \leq 0.05$). The decreasing trend of TTA in the coated samples with C (Table 6) was the lowest (0.73%).

TABLE 5. Effect of coating types on pH of minimally processed kiwi fruit slices during cold storage.

Types*	Storage periods (day)						
	0	2	4	6	8	10	12
A	3.57^{Af}	3.59^{Ce}	3.61^{Ce}	3.64^{Bd}	3.66^{Ac}	3.69^{Ab}	3.73^{Aa}
B	3.60^{Aa}	3.62^{Ba}	3.62^{Ba}	3.66^{Aa}	3.68^{Aa}	3.69^{Aa}	3.71^{BCa}
C	3.60^{Ae}	3.60^{Ce}	3.62^{Bd}	3.65^{ABc}	3.67^{Ab}	3.68^{Ab}	3.70^{Ca}
D	3.58^{Ag}	3.60^{Cf}	3.63^{Bc}	3.65^{ABd}	3.67^{Ac}	3.69^{Ab}	3.72^{ABa}
E	3.60^{Aa}	3.69^{Ab}	3.75^{Ac}	ND	ND	ND	ND*

- See legend to Table (2) for details.

TABLE 6. Effect of coating types on TAA (%) of minimally processed kiwi fruit slices during cold storage (expressed as % of citric acid).

Coating types	Storage periods (days) at 4±1 °C and 70-75%						
	0	2	4	6	8	10	12
A	0.90^{aB}	0.85^{bB}	0.82^{cB}	0.81^{cdA}	0.80^{dA}	0.75^{eA}	0.70^{fD}
B	0.91^{aAB}	0.87^{bA}	0.83^{cA}	0.81^{dA}	0.81^{dA}	0.77^{eA}	0.73^{fC}
C	0.89^{aC}	0.85^{bB}	0.82^{bcB}	0.79^{cdB}	0.79^{deA}	0.78^{deA}	076^{eA}
D	0.91^{aAB}	0.87^{bA}	0.84^{cA}	0.80^{dAB}	0.79^{dA}	0.77^{eA}	0.74^{fB}
E	0.92^{aA}	0.81^{bC}	0.70^{cC}	ND	ND	ND	ND

- See legend to Table (2) for details.

In contrast, this trend for A coated samples was the highest and recorded the lowest value (0.70%) after 12 days of storage compared with 0.70% in uncoated samples (control) after 4 days of storage. Similar trends for TAA were also reported for fresh-cut kiwi fruit by Benitez et al. (2013). Generally, it is declared that the edible coating can decrease gas permeability in slices surface leading to a decrease in respiration rate which could be responsible for the lower TTA in coated slices (Martinez-Romero et al., 2006; Benitez et al., 2013; Song et al., 2013). Bett et al. (2001) reported that, during ripening, organic acids are used as substrates in respiration metabolism, and thereby TTA would be decreased and pH and TSS would be increased.

Ascorbic acid content

Although ascorbic acid is critical for the health, it should be noted that it is sensitive to processing and unstable during storage period. Thus, this vitamin is often used as an indicator of the quality of fruits and vegetables in the distribution chain (Cocetta et al., 2014).The ascorbic acid variations in fresh-cut kiwi fruits are shown in Table (7) Statistical analysis showed that storage period had a significant effect in this respect ($P \leq 0.05$). while significant differences were observed among coated and uncoated samples.

TABLE 7. Effect of coating types on V.C (mg/100g sample) changes of minimally processed kiwi fruit slices during cold storage.

Types*	Storage periods(day)						
	0	2	4	6	8	10	12
A	86Aa	80Cb	79Ac	75Cd	70De	69Df	65Dg
B	87Aa	82Ab	78Bc	75Cd	73Ce	70Cf	67Cg
C	87Aa	81Bb	79Ac	77Ad	77Ad	73Ae	70Af
D	86Aa	82Ab	79Ac	76Bd	75Be	72Bf	68Bg
E	86Aa	78Cb	63Cc	ND	ND	ND	ND*

- See legend of Table 2 for details.

The initial content of ascorbic acid in control sample (86mg/100g) reached 63 mg/100g after 4 days of storage and showed the highest reduction among different treatments. Meanwhile the lowest reduction was found in the C coated samples since ascorbic acid contents reduced from 87 mg/100g to 70 mg/100g followed by D, B, A coated samples after 12 days of cold storage.These results are in agreement with those reported by Allegra et al. (2016). Ascorbic acid is the antioxidant present in fruits and vegetables and usually destroyed after processing (Martin-Diana et al., 2008). The slicing of fruits and vegetables induces oxidative stress, which implies a role of ascorbic acid as antioxidant. The L-ascorbic acid and its oxidation product, L-dehydroascorbic acid, are biologically active. Oxidation of ascorbic acid to dehydroascorbic acid can occur by reactive oxygen species (Cocetta, et al., 2014). In our study the higher levels of ascorbic acid in the coated samples than in control can be attributed to good barrier characteristics of gelatin against oxygen (Andrade et al., 2014) and thus reduction of oxygen levels due to respiration (Benitez et al., 2013).The initial ascorbic acid content in the fresh cut kiwi fruit slices analyzed in this study agrees with the values reported for ripe 'Hayward' kiwi fruits (Gil et al., 2006; Tavarini et al., 2008). During storage, a progressive degradation of ascorbic acid in the coated and untreated slices was also observed by Barberis et al. (2012).

Microbiological analyses

Safety of any food products is critical for the industry. In the present experiment,the microbial load in fresh-cut kiwi fruits slices was determined (Table 8). In uncoated fresh-cut kiwi fruits slices the growth of microorganisms was significantly higher than that present in the treated fruits and there were significant differences between coated samples.

The total bacterial counts (TC) in the fresh-cut kiwi fruits slices were gradually and significantly increased with storage time in all treatments (Table 8).The TC of coated sample with A coating was higher than the other treatments (1.55 and 6.12 log CFU/g at zero and 12 days of storage, resp.) while samples coated with C coatings had the lowest TC compared to the other treatments (1.21 and 4.89 log CFU/g on day zero and 12 of storage period, resp.) significant higher TC was in control samples (2.30 and 7.73 log CFU/g on day zero and day 12 of storage period, resp.).

TABLE 8. Effect of coating types on total bacterial count (TC) and yeasts and moulds count (Y&M) as Log CFU/g* in minimally processed kiwi fruit slices during cold storage.

Coating types	Storage periods(day)							
	TC				Y&M			
	0	4	8	12	0	4	8	12
A	1.55Bd	2.87Bc	4.14Bb	6.12Ba	1.45Bd	1.72Bc	3.37Bb	5.12Ba
B	1.42Cd	1.98Cc	3.85Cb	5.79Ca	1.22Cd	1.70Bc	2.95Cb	4.25Ca
C	1.21Ed	1.73Ec	3.02Eb	4.89Ea	1.10Cd	1.33Dc	2.54Eb	3.98Ea
D	1.34Dd	1.92Dc	3.65Db	5.12Da	1.12Cd	1.62Cc	2.91Db	4.12Da
E	2.30Ad	3.98Ac	5.86Ab	7.73Aa	1.79Ad	2.93Ac	3.84Ab	6.50Aa

- See legend to Table 2 for details.

Similar trend of results was obtained for Y&M counts, since A coating samples had the highest counts and C samples had the lowest counts during storage of kiwi slices. The Y&M count increased from 1.79 logCFU/g to 6.50. in control after 12 days of cold storage, while the lowest increase in thier population was observed in samples coated with C coatings (1.10 and 3.98 log CFU/g, resp.). Such inhibition is in a good agreement with the antimicrobial effects of Aloe vera coating in kiwi fruit slices as given by Benitez et al. (2015)who showed a reduction of yeast and mould counts during storage. Aloe vera extract was also reported to have antimicrobial functions, significantly reducing mesophilic bacteria, and especially have antifungal activity (Valverde et al., 2005; Martinez-Romero et al., 2006). According to the HACCP guidelines, food containing <4 log^{10}cfu/g of organisms is rated "good" and those containing approximately >8 log^{10}cfu/g as spoiled food. In the present study, the TC ranged between 4.89 and 6.12 log cfu/g, which did not exceed this limit of 8 log^{10}cfu/g during storage period of 12 days.

Sensory evaluation

Table 9 shows the colour, taste, odour, texture and over all acceptability scores for the control and for the coated samples. The results revealed that all properties were maintained good even after 12 days. In all the coated samples and no significant ($p<0.05$) differences were observed at zero time of storage. At the beginning of the second day of storage there were significant differences between coated and uncoated samples. The changes in all attributes in the uncoated samples were recorded at day four and were higher than in the other treated samples. This may be related to a decrease in the typical kiwi fruit flavour (O'Connor-Shaw et al., 1994). The panelists gave higher sensory scores to the samples treated with C coatings followed by D, B and A (Table 9). Colour, odour, taste and texture of these fruits were relatively maintained good till 12 days of storage period. This may be due to protective, antifungal and barrier effects of gelatin and Aloe vera, however the non-coated samples received less scores that may be due to high shrinkage, less colour, low quality and fungal deterioration after 4 days of storage. Higher sensory quality of Aloe vera gel-coated apple slices compared to the uncoated ones was also reported by Chauhan et al. (2011) and Song et al. (2013) and in kiwi fruits slices (Benitez et al., 2013) and fresh cut orange (Radi et al., 2017).

TABLE 9. Mean scores of sensorial attributes of minimally processed kiwi fruit slices during cold storage as affected by coating types (Means of 8 panelists).

Storage (Days)	Attributes	A	B	C	D	E
0	Colour	9.5^{Aa}	9.8^{Aa}	9.8^{Aa}	9.8^{Aa}	9.5^{Aa}
	Taste	9.5^{Aa}	9.7^{Aa}	9.7^{Aa}	9.7^{Aa}	9.5^{Aa}
	Odour	9.8^{Aa}	9.9^{Aa}	9.9^{Aa}	9.9^{Aa}	9.8^{Aa}
	Texture	9.9^{Aa}	9.7^{Aa}	9.7^{Aa}	9.7^{Aa}	9.9^{Aa}
	Over all	9.5^{Aa}	9.7^{Aa}	9.7^{Aa}	9.7^{Aa}	9.5^{Aa}
2	Color	9.5^{Aa}	9.5^{Aa}	9.6^{Aa}	9.5^{Aa}	7.5^{Bb}
	Taste	9.5^{Aa}	9.5^{Aa}	9.5^{Aa}	9.5^{Aa}	7.7^{Bb}
	Odor	9.5^{Aa}	9.7^{Aa}	9.8^{Aa}	9.8^{Aa}	7.5^{Bb}
	Texture	9.5^{Aa}	9.5^{Aa}	9.6^{Aa}	9.6^{Aa}	7.0^{Bb}
	Over all	9.5^{Aa}	9.5^{Aa}	9.5^{Aa}	9.5^{Aa}	7.5^{Bb}
4	Colour	9.0^{Ab}	9.0^{Ab}	9.2^{Ab}	9.1^{Ab}	ND
	Taste	9.0^{Bb}	9.0^{Bb}	9.2^{Ab}	9.1^{ABb}	ND
	Odour	9.2^{Bb}	9.3^{Bb}	9.5^{Ab}	9.5^{Ab}	ND
	Texture	9.0^{Bb}	9.0^{Bb}	9.3^{Ab}	9.3^{Ab}	ND
	Over all	9.0^{Bb}	9.0^{Bb}	9.4^{Ab}	9.3^{Ab}	ND
6	Colour	8.3^{Bc}	8.5^{Bc}	9.0^{Ac}	9.0^{Ac}	ND
	Taste	8.0^{Bc}	8.3^{Bc}	8.8^{Ac}	8.7^{Ac}	ND
	Odour	8.0^{Bc}	8.4^{Bc}	9.3^{Ac}	9.0^{Ac}	ND
	Texture	8.5^{Bc}	8.8^{Bc}	9.3^{Ac}	9.1^{Ac}	ND
	Over all	8.0^{Bc}	8.5^{Bc}	9.0^{Ac}	9.0^{Ac}	ND
8	Colour	7.5^{Cd}	8.0^{Bd}	8.6^{Ad}	8.0^{Bd}	ND
	Taste	7.0^{Cd}	7.8^{Bd}	8.5^{Ad}	8.0^{Bd}	ND
	Odour	7.0^{Cd}	7.8^{Bd}	8.7^{Ad}	8.1^{Bd}	ND
	Texture	6.5^{Cd}	7.8^{Bd}	8.6^{Ad}	8.0^{Bd}	ND
	Over all	7.0^{Cd}	7.8^{Bd}	8.8^{Ad}	8.0^{Bd}	ND
10	Colour	7.0^{Ce}	7.4^{Be}	8.0^{Ae}	7.5^{Be}	ND
	Taste	6.5^{Ce}	7.1^{Be}	8.1^{Ae}	7.2^{Be}	ND
	Odour	6.3^{Ce}	7.2^{Be}	8.5^{Ae}	7.5^{Be}	ND
	Texture	6.0^{Ce}	6.7^{Be}	8.3^{Ae}	7.0^{Be}	ND
	Over all	6.0^{Ce}	6.8^{Be}	8.0^{Ae}	7.0^{Be}	ND
12	Colour	6.0^{Cf}	7.0^{Bf}	7.6^{Af}	7.0^{Bf}	ND
	Taste	6.0^{Cf}	6.5^{Bf}	7.3^{Af}	6.8^{Bf}	ND
	Odour	5.8^{Cf}	6.8^{Bf}	7.5^{Af}	6.7^{Bf}	ND
	Texture	5.0^{Cf}	6.5^{Bf}	7.4^{Af}	6.5^{Bf}	ND
	Over all	5.5^{Cf}	6.3^{Bf}	7.5^{Af}	6.5^{Bf}	ND

- See legend of Table 2 for details.

Conclusion

The combination of gelatin and Aloe vera fractions as edible coating materials showed great potential in expanding the shelf-life of fresh-cut kiwi fruits. Gelatinin Aloe vera gel (5:100) and only Aloe vera gel coating preserved the fresh-like quality of kiwi fruits. Extending the shelf life of fresh-cut kiwi fruits to 12 days at 4 ±1°C was achieved.

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