

## Characteristics of Fresh-Cut Guava Coated with *Aloe vera* Gel as Affected by Different Additives

Zuraidah Nasution<sup>1,3,\*</sup>, Justine Ng Wei Ye<sup>2</sup> and Yusnita Hamzah<sup>2</sup>

### ABSTRACT

The effect of additives in *Aloe vera* (AV) gel coating was investigated on fresh-cut guava stored at 5 °C and 75–80% relative humidity. Eight treatments were employed involving three additives and their combinations. A control sample coated only with AV gel and a comparison sample of uncoated fresh-cut guava were also prepared. The additives used were 1.5% ascorbic acid (AA), 2% calcium chloride (CaCl<sub>2</sub>), and 0.2% potassium sorbate (PS). Additives helped to extend the shelf life of the coated samples, with PS and AA giving the highest inhibition effects. AV + CaCl<sub>2</sub>-coated guava showed the lowest weight loss ( $3.57 \pm 0.39\%$ ) whilst maintaining sufficient hardness. The coated samples had less change in the color lightness and yellowness compared to the uncoated sample. Five selected coated samples and a fresh uncoated sample were then subjected to sensory acceptance testing. AV + AA + PS-coated guava was the most acceptable sample. Moreover, it gave the highest ascorbic acid content ( $190.00 \pm 14.14$  mg per 100 g). With suitable additives, AV gel has potential as an edible coating for fresh-cut guava due to its ability to prolong the shelf life and maintain characteristics of the fruit for a longer time.

**Keywords:** *Aloe vera*, fresh-cut fruits, edible coating, shelf life, guava

### INTRODUCTION

The freshness and appearance at the time of purchase determine the quality of fresh-cut fruits (Kader, 2002). Minimal processing of fresh-cut fruits, which involves grading, washing, sorting, peeling, slicing and packaging, can affect the integrity of the fruits and cause biochemical changes and microbial spoilage that may result in degradation of the color, texture and flavor of fruits (Watada and Qi, 1999). The removal of the natural protective skin of fruits causes leakage of juices and sugars from the damaged tissue resulting in the fruits being highly susceptible to microbial

spoilage (Oms-Oliu *et al.*, 2010).

An edible coating can be used as an alternative to modified atmosphere packaging to improve the shelf life of fresh-cut fruits by reducing quality changes and quality loss during storage (Rojas-Grau *et al.*, 2009a). An edible coating can serve as a barrier to moisture migration, gas diffusion and microbial invasion to maintain the quality of fresh-cut fruits. It can be prepared from major components such as polysaccharides, proteins and lipids, added with minor components such as additives (antioxidants, texture enhancers and antimicrobial agents) and plasticizers (glycerine). Minor components are

<sup>1</sup> Department of Community Nutrition, Faculty of Human Ecology, Bogor Agricultural University, Bogor 16680, Indonesia.

<sup>2</sup> School of Food Science and Technology, Universiti Malaysia Terengganu, Kuala Terengganu 21030, Malaysia.

<sup>3</sup> Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok 10900, Thailand.

\* Corresponding author, e-mail: g5618000296@ku.ac.th; z.nasution@hotmail.com

used to modify the mechanical, functional and nutritional properties of edible coating (Rojas-Grau *et al.*, 2010).

*Aloe vera* gel has potential to be used as an edible coating for fresh-cut fruits as it contains various polysaccharides (Pugh *et al.*, 2001). Studies have been conducted on the use of *Aloe vera* gel as an edible coating for table grapes, sweet cherry, nectarine, apples and apple slices (Valverde *et al.*, 2005; Martinez-Romero *et al.*, 2006; Serrano *et al.*, 2006; Ahmed *et al.*, 2009; Chauhan *et al.*, 2011; Ergun and Satici, 2012). However, its application on fresh-cut guava has not been explored. Thus, the objectives of this study were to investigate the effect of *Aloe vera* gel containing additives as an edible coating on the microbiological shelf life, physical characteristics, ascorbic acid content and sensory acceptance of fresh-cut guava.

Through this study, information could be collected about the effect of additives such as antioxidants, texture enhancers and antimicrobial agents in *Aloe vera* gel as an edible coating for fresh-cut guava. Moreover, this study would add to the variety of sources of edible coatings. The common sources of edible coatings used for fresh-cut fruits, such as chitosan, starch, carrageenan, whey protein and casein, are not as easily available as *Aloe vera* plants. Currently, *Aloe vera* gel is used in the production of beverages, tablets, lotions, shampoo and soap. Thus, the possible use of *Aloe vera* gel as an edible coating can add variety to its usage.

## MATERIALS AND METHODS

### Materials

Guava (*Psidium guajava* L.) fruits of the variety Kampuchea harvested from a farm in Tangkok, Johor, Malaysia were purchased from a local supplier in Batu Enam, Kuala Terengganu, Malaysia. Fruits were selected with a maturity index of 2 (yellowish green color, uniform shape and size and free from defects). The guava maturity

index was determined based on the standard developed by the Federal Agricultural Marketing Authority of Malaysia (n.d). After purchase, the guava fruits were stored at 5 °C before further processing.

Fresh, whole *Aloe vera* (*Aloe barbadensis* Miller) leaves from one-year-old plants were purchased from a commercial plant nursery in Kuala Terengganu, Malaysia.

For use in the production of the *Aloe vera* gel, plasticizer (glycerine) and activated carbon were purchased from local suppliers in Kuala Terengganu, Malaysia, and the additives used (ascorbic acid, calcium chloride and potassium sorbate) were purchased from a chemical supplier in Selangor, Malaysia.

### Methods

The experimental unit used in this study was fresh-cut guava. Whole guava samples were washed and the skin was peeled off. The guava seeds were removed and the flesh was cut into cubes of 2 × 2 × 1.5 cm. The cubes were washed and coated by dipping them in the coating solution for 5 min followed by draining for 1 min and light drying at 30 °C for 20 min in a cabinet dryer. The coated cubes were then placed on a polystyrene plate, wrapped with cling wrap, and stored at 5 °C with a relative humidity of 75–80% (Olivas *et al.*, 2003).

*Aloe vera* gel preparation was undertaken according to Ramachandra and Rao (2008), who advised that *Aloe vera* leaves must be processed within 2 hr of harvesting to prevent oxidation of the gel due to exposure to air. Whole leaves were washed with water and the base and tips of the leaves along with its spikes were removed. Next, the skin was carefully separated from parenchyma to obtain *Aloe vera* flesh. The flesh was then washed and blanched in hot water at 100 °C for 4 min. The blanched flesh was then blended and the *Aloe vera* gel obtained was filtered through activated carbon to remove anthraquinones that have a laxative effect. Before pasteurization, the

pH of the gel was adjusted to 3.0 by the addition of citric acid to stabilize and prevent browning. The process was then continued with pasteurization at 85 °C for 1 min. After pasteurization, the gel was quickly cooled to 5 °C or below. Finally, the *Aloe vera* gel was filled into pre-sterilized, opaque glass bottles for storage in a chiller at 5 °C and 75–80% relative humidity.

The independent variables of this study were eight treatments consisting of three types of additives used in the *Aloe vera* gel as a coating on the fresh-cut guava, as shown in Table 1. The percentage used for each type of additive was determined through a series of preliminary studies (results are not presented here). An uncoated sample was also prepared for comparison. The dependent variables consisted of the microbiological shelf life (total plate count and yeast and mould count), physical characteristics (weight loss percentage, hardness and color), chemical characteristic (ascorbic acid content) and sensory acceptance (color, odor, texture, taste and overall acceptance). Samples were produced in duplicate using a completely randomized design.

The microbiological shelf life was determined using aerobic plate counts and yeast and mould counts following the methods described in Djouia *et al.* (2010), while the weight loss percentage relative to the initial weight of the guava was determined by weighing using an analytical balance (Ismail *et al.*, 2010).

A texture analyzer was used to test the hardness of the samples following the method described by (Tian, 2005). A compression test was performed using a 2 mm diameter stainless steel cylinder probe with a 5 kg load size and a pre-test speed of 5 mm.s<sup>-1</sup>, a test speed of 4 mm.s<sup>-1</sup> and a post test speed of 5 mm.s<sup>-1</sup>. When the probe had touched the sample and traveled to a depth of 2 mm, the resistance exerted by the sample was recorded.

Following the method described by Ganjloo *et al.* (2009), the color of samples was measured using a colorimeter with a Minolta standard white plate used for calibration. Four different locations at each sample were measured and the average value was obtained.

Titration with iodine solution was used to analyze the ascorbic acid content of samples. The end point of titration was determined using 1% starch indicator solution, while the sample solution was prepared by homogenizing 10 g of guava cubes with 100 mL of distilled water and centrifuged at 2,300×g for 10 min. Then, the supernatant obtained was filtered and the sample solution was prepared by diluting 1 mL of supernatant with 25 mL of distilled water (College of Science University of Canterbury, n.d.).

A sensory affective (acceptance) test was conducted in the laboratory using 30 untrained panelists on the five selected treatments in addition to the control and one fresh-cut guava sample. A

**Table 1** Types of additives used for each treatment.

Treatment	1.5% ascorbic acid (AA)	2% calcium chloride (CaCl <sub>2</sub> )	0.2% potassium sorbate (PS)
A (control)		-	-
B	✓	-	-
C	-	✓	-
D	-	-	✓
E	✓	✓	-
F	✓	-	✓
G	-	✓	✓
H	✓	✓	✓

✓ = Included in the treatment.

seven-point hedonic scale (1 = dislike extremely, 4 = neither like nor dislike, and 7 = like extremely) was used. Each panelist was required to evaluate samples for their color, odor, texture, taste and overall acceptance (Stone and Sidel, 1993).

### Data analysis

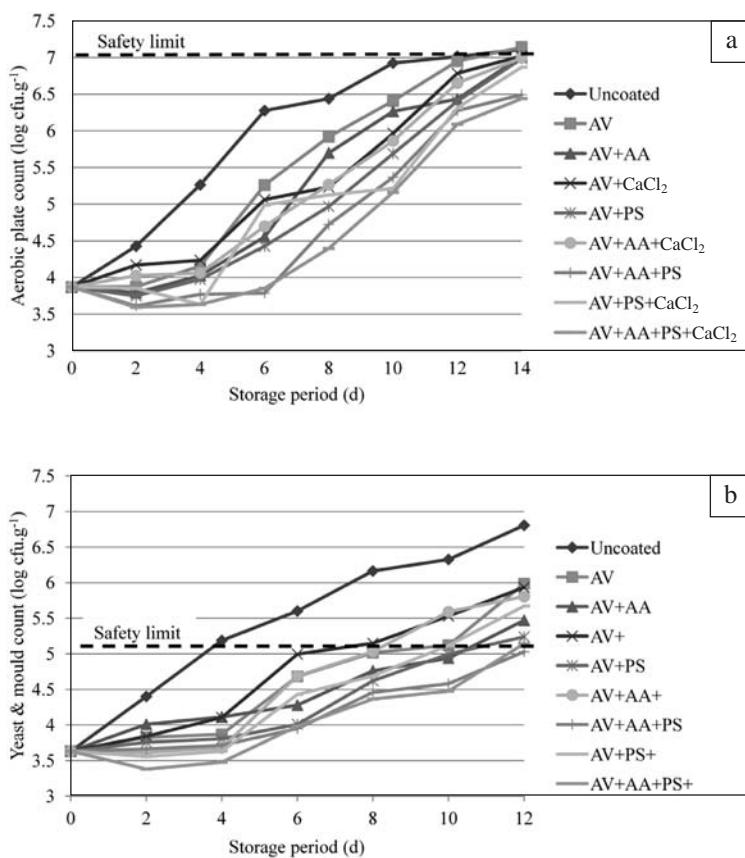
Statistical analysis was performed using the Minitab computer software package (version 14; Minitab Inc.; State College, PA, USA). Data obtained from the experiment were expressed as the mean value  $\pm$  SD. One-way analysis of variance was used to evaluate significant differences among treatments followed by Fisher's least significant difference test to compare the mean values.

Statistical analysis was made at the confidence level of  $P < 0.05$ .

## RESULTS AND DISCUSSION

### Microbiological shelf life

Figure 1 shows the effect of additives in the *Aloe vera* gel on the aerobic plate count and yeast and mould count of fresh-cut guava. The aerobic microbial counts for all coated samples increased rapidly starting from day 4, while for the uncoated sample, the microbial count started to increase even from day 2. By day 10, uncoated guava had reached a microbial count of 7 log colony forming units (cfu).g<sup>-1</sup>, which is the safety



**Figure 1** Effect of additives in *Aloe vera* (AV) gel on fresh-cut guava during 12 d storage (5 °C; 75-80% relative humidity) on (a) Aerobic plate count and (b) Yeast and mould count. (cfu = Colony forming units; AA = 1.5% Ascorbic acid; CaCl<sub>2</sub> = 2% Calcium chloride; PS = 0.2% Potassium sorbate.)

limit for aerobic bacteria in fresh-cut fruits (Barth *et al.*, 2004). At day 14, the highest microbial count was found in the uncoated sample followed by guava coated only with AV, while the lowest microbial count was observed in guava treated with AV + AA + PS and AV + AA + PS + CaCl<sub>2</sub>, which had not reached the safety limit until day 14.

The AV-coated guava samples had lower microbial counts compared to the uncoated guava samples due to the antimicrobial properties of the AV gel that helped to delay microbial proliferation (Oms-Oliu *et al.*, 2010). AV gel was reported to effectively kill or greatly reduce or eliminate the growth of microorganisms such as *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Propionibacterium acne*, *Helicobacter pylori* and *Salmonella typhi*, due its content of pyrocatechol, cinnamic acid and p-coumaric acid (Lawrence, 2009).

The incorporation of additives such as ascorbic acid, calcium chloride and potassium sorbate in the AV gel helped to delay the microbial growth in fresh-cut guava. The AV + CaCl<sub>2</sub>-coated guava had a lower microbial count compared to the uncoated guava due to the presence of calcium that enhanced tissue resistance to bacterial attack by stabilizing and strengthening cell walls (Luna-Guzman and Baret, 2000). However, compared to the other guava samples coated with different additives, the sample coated with AV + CaCl<sub>2</sub> was found to have a higher microbial count. Thus, it can be concluded that the addition of only CaCl<sub>2</sub> was less efficient in delaying microbial growth compared to the other additives.

The addition of an organic acid such as ascorbic acid increases the proton concentration leading to an increase in the acidity and a decrease in the pH (Oms-Oliu *et al.*, 2010). Thus, the growth of microorganisms in the guava samples was inhibited when the pH fell below the optimum range needed for their growth.

The fresh-cut guava coated with AV

gel incorporated with potassium sorbate or a combination of potassium sorbate with the other additives had a generally lower microbial count than the other samples. This condition was related to the dissociation constant of acid (pKa), which is the pH level where 50% of the acid is in a dissociated state while the other 50% is in an undissociated state. The undissociated state of an acid is responsible for its antimicrobial activities (Oyarzabal and Backert, 2012). The pKa for sorbic acid is 4.75, which means the antimicrobial effect of potassium sorbate increases as the pH decreases below 4.75 since the proportion of the undissociated form of sorbic acid increases above 50% (Dharmadhikari, n.d.). Therefore, the AV gel with a pH value of about 3.0 produced a lower microbial count when it was used in combination with potassium sorbate. This synergistic effect in controlling microorganism growth was observed in samples coated with AV + AA + PS and AV + AA + PS + CaCl<sub>2</sub>.

The yeast and mould count of the uncoated guava sample increased rapidly from day 2, and on day 4, it had already exceeded the safety limit for yeast and mould count of log 5 cfu.g<sup>-1</sup> (Barth *et al.*, 2004). According to Saks and Barkai-Golan (1995), AV gel is effective against plant pathogenic fungi such as *Penicillium digitatum*, *Botrytis cinerea* and *Alternaria alternata*. The antifungal activity of AV gel is based on its ability to suppress germination and inhibit mycelial growth due to the presence of more than one active compound with antifungal activity (Valverde *et al.*, 2005). A yeast count exceeding log 5 cfu.g<sup>-1</sup> can cause an off odor in cut fruits due to the fermentation of sugars resulting in ethanol, organic acid and volatile esters (Rojas-Grau *et al.*, 2007).

For all coated samples, the yeast and mould counts remained relatively low until day 4, and then from day 4 onward, the count started to increase, especially in the guava coated with AV + CaCl<sub>2</sub>. By day 6, samples of guava coated with AV + CaCl<sub>2</sub> had achieved a microbial count of log 5 cfu.g<sup>-1</sup>, which was faster than for the other coated

samples. Calcium chloride is dissociated into calcium and chloride ions when incorporated in AV gel; Omoifo (2011) reported that the presence of calcium ions supported yeast induction and proliferation. Thus, calcium chloride had less of an inhibitory effect on yeast and mould compared to ascorbic acid and potassium sorbate.

By the end of day 12, the lowest yeast and mould count was found in guava coated with AV + AA + PS, which had finally reached the end of its shelf life. Sorbic acid is considered effective on yeast and mould and the presence of ascorbic acid in AV + AA + PS further reduced the pH of the coating solution, which caused an increased proportion of the undissociated form of sorbic acid that inhibited the growth of yeast and mould and extended the shelf life of the sample (Dauthy, 1995).

#### Weight loss percentage, hardness and color

Table 2 shows the weight loss percentage of samples after 12 d of storage. Fresh-cut fruits are prone to weight loss due to the removal of skin that exposes the fruit's internal tissues (Watada and Qi, 1999). Water loss involves a difference

in the gradient of water vapor pressure between the internal parts of the fruit and the environment outside, which causes moisture loss from fresh-cut fruit by vapor phase diffusion (Mafsoonazad and Ramaswamy, 2005).

By day 12, all coated guava samples had a lower weight loss percentage compared to the uncoated guava sample. AV gel has been reported to have hygroscopic properties, which results in the formation of a water barrier between the sample and the environment that prevents the transfer of water (Valverde *et al.*, 2005).

Guava coated with AV + PS + CaCl<sub>2</sub> had the lowest weight loss percentage after 12 d of storage. Calcium chloride is effective in maintaining the structural integrity of fresh-cut fruits resulting in a lower weight loss percentage (Pila *et al.*, 2010). However, when AA was added in the CaCl<sub>2</sub> treatment, the coated sample had the highest weight lost percentage that was almost similar to the uncoated sample. The presence of ascorbic acid rapidly consumes oxygen in the headspace of a packaged sample (Rojas-Grau *et al.*, 2007). In the presence of a low level of oxygen, anaerobic degradation of ascorbic acid occurs

**Table 2** Effect (mean  $\pm$  SD) of additives in *Aloe vera* (AV) gel on weight loss percentage, hardness, and color of fresh-cut guava after 12 d storage (5 °C; 75-80% relative humidity).

Treatment	Observations				
	Weight loss (%)	Hardness (g)	Lightness (L*)	Redness (a*)	Yellowness (b*)
Fresh guava	-	683.43 $\pm$ 20.24	95.00 $\pm$ 5.32	-3.88 $\pm$ 0.48	+39.635 $\pm$ 1.28
Uncoated	15.06 $\pm$ 0.02	189.65 $\pm$ 30.68	62.88 $\pm$ 1.98	+6.86 $\pm$ 0.11	+53.30 $\pm$ 0.45
AV	9.92 $\pm$ 0.07 <sup>ab</sup>	303.36 $\pm$ 63.40 <sup>de</sup>	73.71 $\pm$ 3.63 <sup>d</sup>	+6.93 $\pm$ 0.34 <sup>a</sup>	+50.54 $\pm$ 4.29 <sup>ab</sup>
AV + AA	11.55 $\pm$ 3.35 <sup>ab</sup>	265.23 $\pm$ 46.94 <sup>e</sup>	82.81 $\pm$ 1.22 <sup>ab</sup>	-1.37 $\pm$ 0.41 <sup>b</sup>	+52.52 $\pm$ 3.51 <sup>a</sup>
AV + CaCl <sub>2</sub>	3.57 $\pm$ 0.39 <sup>c</sup>	503.22 $\pm$ 28.30 <sup>ab</sup>	81.77 $\pm$ 1.33 <sup>bc</sup>	-2.73 $\pm$ 0.19 <sup>bc</sup>	+44.37 $\pm$ 1.94 <sup>bc</sup>
AV + PS	8.66 $\pm$ 1.14 <sup>b</sup>	492.48 $\pm$ 69.25 <sup>abc</sup>	80.34 $\pm$ 0.64 <sup>bc</sup>	-4.10 $\pm$ 0.18 <sup>c</sup>	+45.96 $\pm$ 5.71 <sup>abc</sup>
AV + AA + CaCl <sub>2</sub>	14.04 $\pm$ 2.69 <sup>a</sup>	452.06 $\pm$ 51.18 <sup>abc</sup>	81.91 $\pm$ 2.82 <sup>bc</sup>	-7.35 $\pm$ 0.26 <sup>d</sup>	+46.81 $\pm$ 4.84 <sup>abc</sup>
AV + AA + PS	11.16 $\pm$ 2.19 <sup>ab</sup>	392.09 $\pm$ 0.14 <sup>cd</sup>	77.81 $\pm$ 0.82 <sup>cd</sup>	-9.31 $\pm$ 1.43 <sup>d</sup>	+44.66 $\pm$ 0.76 <sup>abc</sup>
AV + PS + CaCl <sub>2</sub>	10.86 $\pm$ 1.78 <sup>ab</sup>	431.13 $\pm$ 58.37 <sup>bc</sup>	82.79 $\pm$ 0.25 <sup>ab</sup>	-11.90 $\pm$ 2.01 <sup>e</sup>	+42.31 $\pm$ 2.81 <sup>c</sup>
AV + AA + PS + CaCl <sub>2</sub>	9.16 $\pm$ 0.12 <sup>b</sup>	558.78 $\pm$ 0.11 <sup>a</sup>	86.31 $\pm$ 1.70 <sup>a</sup>	-7.94 $\pm$ 0.33 <sup>d</sup>	+41.76 $\pm$ 0.71 <sup>c</sup>

AA = 1.5% ascorbic acid; CaCl<sub>2</sub> = 2% Calcium chloride; PS = 0.2% Potassium sorbate.

Lightness, redness and yellowness based on Hunter Associates Library Inc. (2012).

Values with different superscript letters within the same column are significantly different ( $P < 0.05$ ).

followed by the production of carbon dioxide and a high level of carbon dioxide softens tissues leading to the formation of exudates that are often found as droplets on the surface of the sample (Rojas-Grau *et al.*, 2009a).

After 12 d of storage, the hardness of all samples decreased and the uncoated guava sample had a lower hardness than the coated samples. AV gel has been reported to restrict softening of sweet cherry, due to a lower rate of water loss (Martinez-Romero *et al.*, 2006).

The addition of calcium chloride individually or in combination with ascorbic acid and potassium sorbate in the AV gel caused hardness retention due to the presence of calcium ions that form a complex with the cell wall and middle-lamella pectin, leading to an improvement in the structural integrity. Moreover, calcium also increases the membrane integrity leading to increased cell turgor pressure (Luna-Guzman and Barrett, 2000).

Guava coated with AV + AA had significantly lower hardness compared to samples coated with AV added with the other additives. Ascorbic acid is easily oxidized by oxygen left in the headspace of the packaging, thus creating low oxygen conditions that could lead to tissue breakdown (Rojas-Grau *et al.*, 2007; Rojas-Grau *et al.*, 2009a).

The color lightness values of all samples generally decreased after 12 d of storage. Supapvanich and Tucker (2011) stated that a decrease in the lightness in stored fresh-cut fruit is usually related to the development of a translucent condition or water-soaking symptoms.

At the end of the storage period, the uncoated sample had lower lightness and higher redness and yellowness compared to samples coated with AV gel with additives. Coating of fresh-cut fruit with AV gel causes the creation of modified atmosphere conditions that help to delay chlorophyll degradation and carotenoid synthesis (Ergun and Satici, 2012). Interestingly, the sample coated only with AV had the lowest lightness and

highest redness after storage, which was most likely caused by non-enzymatic browning of some leftover anthraquinone that might exist in the AV gel (Ramachandra and Rao, 2008).

Guava coated with AV + CaCl<sub>2</sub> + PS had the lowest redness, indicating less browning occurred due to the presence of potassium sorbate that helped to prevent the growth of any yeast and mould that could cause surface discoloration on fresh-cut fruits (Barth *et al.*, 2004; Dharmadhikari, n.d.). CaCl<sub>2</sub> can also help in preventing surface discoloration because of its calcium ion that modulates the activity of polyphenol oxidase (Oms-Oliu *et al.*, 2010).

The yellowness of the samples generally increased during storage due to enzymatic browning by polyphenol oxidase and the formation of peophytin (Gil *et al.*, 1998). In samples coated with AV + AA, ascorbic acid acts as an anti-browning agent that reduces quinones, generated by the oxidation of polyphenols by polyphenol oxidase, back to phenolic substrates. However, ascorbic acid is oxidized to dehydroascorbic acid after some time, leading to the accumulation of *o*-quinones and browning. Thus, though ascorbic acid is an antioxidant, it only provides temporary protection against enzymatic browning (Rojas-Grau *et al.*, 2009b).

### Ascorbic acid content

For the ascorbic acid analysis and sensory acceptance test, samples were stored only for 6 d as it was the safest shelf life limit concluded from microbiological shelf life analysis. Figure 2 illustrates the ascorbic acid content of samples after 6 d storage.

After 6 d of storage, the coated and uncoated guava samples showed a reduction in the ascorbic acid content due to loss during processing as well as during storage through leaching, oxidation and enzymatic degradation (Lee and Kader, 2000).

After storage, the uncoated sample was found to have a lower ascorbic acid content than

the coated samples. Serrano *et al.* (2006) reported that AV gel used as a coating for table grapes was able to maintain the grapes' total phenolic content, ascorbic acid content and total antioxidant activity when stored for 35 d at 1 °C.

Interestingly, the samples of AV + AA coated guava had the lowest ascorbic acid content among all coated samples. Due to the presence of carbon dioxide coming from anaerobic oxidation in the packaging, the oxidation of ascorbic acid was stimulated, leading to a lower content of ascorbic acid at the end of the storage period (Lee and Kader, 2000). The samples of AV + AA + PS-coated guava had the highest retention of ascorbic acid. The presence of sorbic acid in potassium sorbate can prevent ascorbic acid oxidation since the free radicals (OH and O<sub>2</sub>) oxidize sorbic acid instead of ascorbic acid (Durrani *et al.*, 2011).

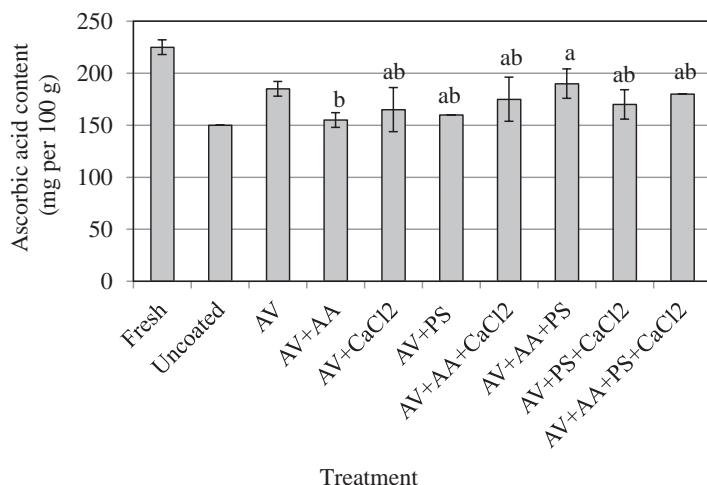
### Sensory acceptance

Based on their microbiological shelf life and physicochemical characteristics, four treatments (AV + CaCl<sub>2</sub>, AV + AA + PS, AV + PS + CaCl<sub>2</sub> and AV + AA + PS + CaCl<sub>2</sub>) were selected to be subjected through sensory acceptance test

along with samples coated only with AV gel and fresh, uncoated samples. Table 3 shows the sensory acceptance scores of samples after 6 d of storage.

Fresh, uncoated guava and AV + AA + PS-coated + CaCl<sub>2</sub> guava had the highest color acceptance score. Through measurement with a colorimeter (Table 2), AV + AA + PS-coated + CaCl<sub>2</sub> guava was also found to have high lightness and low redness and yellowness, indicating less browning had occurred during storage. Guava coated only with AV gel had significantly lower color acceptance compared to fresh uncoated guava due to the possible presence of leftover anthraquinones that could cause non-enzymatic browning (Ramachandra and Rao, 2008).

For odor acceptance, samples coated with AV + AA + PS + CaCl<sub>2</sub> received the highest score which was significantly different to the samples coated with AV gel only. Therefore, the combined use of these additives in AV gel could be considered successful in maintaining the sensory characteristic of fresh-cut guava, especially odor.



**Figure 2** Effect of additives in *Aloe vera* (AV) gel on ascorbic acid content of fresh-cut guava after 6 d storage (5 °C; 75–80% relative humidity). Bars with different lowercase letters are significantly different at  $P < 0.05$ . Where large enough differences occur to show, the vertical error bars indicate  $\pm$  SD. (AA = 1.5% ascorbic acid; CaCl<sub>2</sub> = 2% Calcium chloride; PS = 0.2% Potassium sorbate.)

**Table 3** Effect (mean  $\pm$  SD) of additives in *Aloe vera* (AV) gel on sensory acceptance of fresh-cut guava after 6 d storage (5 °C; 75–80% relative humidity).

Treatment	Sensory Acceptance Score				
	Color	Odor	Texture	Taste	Overall acceptance
Fresh, uncoated	5.13 $\pm$ 1.20 <sup>a</sup>	4.67 $\pm$ 1.56 <sup>ab</sup>	4.47 $\pm$ 1.14 <sup>a</sup>	4.47 $\pm$ 1.31 <sup>ab</sup>	4.67 $\pm$ 1.12 <sup>ab</sup>
AV	3.93 $\pm$ 1.57 <sup>b</sup>	3.97 $\pm$ 1.27 <sup>c</sup>	4.80 $\pm$ 1.40 <sup>a</sup>	4.47 $\pm$ 1.41 <sup>ab</sup>	4.53 $\pm$ 1.43 <sup>ab</sup>
AV + CaCl <sub>2</sub>	4.70 $\pm$ 1.12 <sup>a</sup>	4.30 $\pm$ 1.32 <sup>abc</sup>	4.63 $\pm$ 1.27 <sup>a</sup>	4.10 $\pm$ 1.40 <sup>ab</sup>	4.33 $\pm$ 1.03 <sup>ab</sup>
AV + CaCl <sub>2</sub> + PS	4.50 $\pm$ 1.11 <sup>ab</sup>	4.00 $\pm$ 1.11 <sup>bc</sup>	4.43 $\pm$ 1.10 <sup>a</sup>	3.77 $\pm$ 1.41 <sup>b</sup>	4.07 $\pm$ 1.17 <sup>b</sup>
AV + AA + PS	4.87 $\pm$ 1.25 <sup>a</sup>	4.53 $\pm$ 1.46 <sup>abc</sup>	4.53 $\pm$ 1.48 <sup>a</sup>	4.70 $\pm$ 1.53 <sup>a</sup>	4.87 $\pm$ 1.43 <sup>a</sup>
AV + AA + CaCl <sub>2</sub> + PS	5.13 $\pm$ 1.25 <sup>a</sup>	4.73 $\pm$ 1.31 <sup>a</sup>	4.80 $\pm$ 1.19 <sup>a</sup>	3.93 $\pm$ 1.55 <sup>b</sup>	4.43 $\pm$ 1.25 <sup>ab</sup>

AA = 1.5% ascorbic acid; CaCl<sub>2</sub> = 2% Calcium chloride; PS = 0.2% Potassium sorbate.

Values with different superscript letters within the same column are significantly different ( $P < 0.05$ ).

There were no significant differences among samples in their acceptance scores for texture after 6 d storage. According to the results from the texture analysis (Table 2), all coated samples had relatively high hardness values. Therefore, the AV gel itself, or in combination with additives, was effective in maintaining the hardness of fresh-cut guava.

The samples of guava coated with AV + AA + PS had the highest taste acceptance and overall acceptance scores and it was significantly different from the other samples that used calcium chloride in their coating formulation. The absence of calcium chloride, which could impart bitterness, helped to improve the sensory acceptance of samples (Luna-Guzman and Baret, 2000).

## CONCLUSION

This study showed the effectiveness of additives in AV gel, especially PS and AA, in delaying the microbial deterioration of fresh-cut guava. Additives in AV gel also caused a reduction in the weight loss percentage in fresh-cut guava with a significant reduction observed for guava coated with AV + CaCl<sub>2</sub>. The presence of additives such as CaCl<sub>2</sub> was found to be effective in maintaining the hardness of fresh-cut guava during storage. Additives also helped in preserving

the color of fresh-cut guava coated with AV gel. Guava coated with AV + AA + PS had the highest retention of ascorbic acid and also gained the highest overall acceptance score by the panelists. This treatment also managed to delay microbial spoilage, decrease the weight loss percentage and inhibit browning; thus, it was selected as the best treatment.

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