ALOE VERA EDIBLE COATING RETAINS THE BIOACTIVE COMPOUNDS OF WAX APPLES (Syzygium samarangense)

AIDILLA MUBARAK* and THEVINTA RAO ENGAKANAH

School of Food Science and Technology, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu
*E-mail: aidilla@umt.edu.my

Accepted 20 November 2017, Published online 31 December 2017

ABSTRACT

Postharvest loss of wax apples often occurs as a result of its high deterioration rate during storage. This study aims to determine the efficacy of different concentration of aloe vera gel used as edible coating on retaining the nutrient content in wax apples as well as maintaining other postharvest quality of wax apples in the particular storage period and temperature. Effectiveness of the edible coating on retaining the quality of wax apples was assessed by measuring vitamin C content, total anthocyanin content, total flavonoid content, weight loss, titratable acidity and firmness. Total anthocyanin was measured using pH differential method, while total flavonoid was measured using aluminum chloride colorimetric assay. Different concentrations of aloe vera gel were used to coat the wax apples. This study finds that 100% aloe vera gel is effective in retaining the bioactive constituents including vitamin C, total anthocyanin and total flavonoid content of stored wax apples. Aloe vera gel coating at the same concentration also has a tendency to reduce loss of weight and firmness of wax apples, although no significant difference was observed. The edible coating is shown to have the potential to be commercially used in retaining quality of stored wax apples.

Key words: Aloe vera, edible coating, wax apple, bioactive compounds, antioxidants

INTRODUCTION

Syzygium samarangense (wax apple) is an economically valuable fruit, widely cultivated and grown throughout Malaysia, Thailand, Indonesia and Taiwan (Moneruzzaman et al., 2011). A wax apple, which is also known as jambu air in Malaysia, has a waxy and glossy appearance, large size with small seeds, crunchy, watery, sweet taste, and subtle flavour, making it a popular exotic fruit. However, wax apples are the perishable fruit that deteriorate rapidly after harvest which results in reduced market value as well as postharvest losses (Akamine & Goo, 1979).

Edible coating is suggested to be useful for maintaining the quality of fresh foods including fruits and vegetables. Apart from various common polymers used as edible coating such as gelatin, starch, chitosan, and zein; aloe vera also has the potential to be used as edible coating because of its rich source of polysaccharide (Surjushe et al., 2008). Aloe vera also contains a high amount of bioactive compounds including vitamin and phenolics (Femenia et al., 1999) and does not add the unfavourable properties to the foodstuff. Application of aloe vera gel as the edible coating is found to retain the bioactive compound such as ascorbic acid (Misir et al., 2014) and maintain the quality traits of several fruits, such as sweet cherry, nectarines and table grapes (Valverde et al., 2005; Martinez-Romero et al., 2006; Ahmed et al., 2009; Castillo et al., 2010). There is a possibility that aloe vera can retain the quality of wax apples when applied as the edible coating that can be an alternative for postharvest chemical treatments. Thus, this study aims to evaluate the effect of aloe vera being applied as the edible coating on retaining the bioactive compounds as well as other physicochemical parameters related to fruit quality of wax apples.

Edible coatings made from aloe vera gel at different concentrations (50, 75, and 100 v/v %) were applied on the wax apples, and stored for 12 days at 10°C. The changes of ascorbic acid, anthocyanin and flavonoids were measured to evaluate the effectiveness of aloe vera gel-based coatings including vitamin and phenolics (Femenia et al., 1999) and does not add the unfavourable properties to the foodstuff. Application of aloe vera gel as the edible coating is found to retain the bioactive compound such as ascorbic acid (Misir et al., 2014) and maintain the quality traits of several fruits, such as sweet cherry, nectarines and table grapes (Valverde et al., 2005; Martinez-Romero et al., 2006; Ahmed et al., 2009; Castillo et al., 2010). There is a possibility that aloe vera can retain the quality of wax apples when applied as the edible coating that can be an alternative for postharvest chemical treatments. Thus, this study aims to evaluate the effect of aloe vera being applied as the edible coating on retaining the bioactive compounds as well as other physicochemical parameters related to fruit quality of wax apples.

Edible coatings made from aloe vera gel at different concentrations (50, 75, and 100 v/v %) were applied on the wax apples, and stored for 12 days at 10°C. The changes of ascorbic acid, anthocyanin and flavonoids were measured to evaluate the effectiveness of aloe vera gel-based coatings including vitamin and phenolics (Femenia et al., 1999) and does not add the unfavourable properties to the foodstuff. Application of aloe vera gel as the edible coating is found to retain the bioactive compound such as ascorbic acid (Misir et al., 2014) and maintain the quality traits of several fruits, such as sweet cherry, nectarines and table grapes (Valverde et al., 2005; Martinez-Romero et al., 2006; Ahmed et al., 2009; Castillo et al., 2010). There is a possibility that aloe vera can retain the quality of wax apples when applied as the edible coating that can be an alternative for postharvest chemical treatments. Thus, this study aims to evaluate the effect of aloe vera being applied as the edible coating on retaining the bioactive compounds as well as other physicochemical parameters related to fruit quality of wax apples.

Edible coatings made from aloe vera gel at different concentrations (50, 75, and 100 v/v %) were applied on the wax apples, and stored for 12 days at 10°C. The changes of ascorbic acid, anthocyanin and flavonoids were measured to evaluate the effectiveness of aloe vera gel-based coatings including vitamin and phenolics (Femenia et al., 1999) and does not add the unfavourable properties to the foodstuff. Application of aloe vera gel as the edible coating is found to retain the bioactive compound such as ascorbic acid (Misir et al., 2014) and maintain the quality traits of several fruits, such as sweet cherry, nectarines and table grapes (Valverde et al., 2005; Martinez-Romero et al., 2006; Ahmed et al., 2009; Castillo et al., 2010). There is a possibility that aloe vera can retain the quality of wax apples when applied as the edible coating that can be an alternative for postharvest chemical treatments. Thus, this study aims to evaluate the effect of aloe vera being applied as the edible coating on retaining the bioactive compounds as well as other physicochemical parameters related to fruit quality of wax apples.
edible coating on retaining the bioactive compounds in wax apples. Other parameters related to quality including the weight loss, titratable acidity and firmness were also measured.

In this study, aloe vera edible coating was observed to help in retaining vitamin C, anthocyanin, and flavonoids content in wax apple. The edible coating also shows a tendency for reducing the weight loss of wax apples and delaying the increase of titratable acidity which is in line with the delayed deterioration.

MATERIALS AND METHODS

Materials
Fresh wax apples at the maturity stage of four (wax apples with red and glossy skin that is safe for consumption) were obtained. The fruits is of regular shape, uniform size and no defect. The aloe vera plant species Barbadensis miller was obtained from Aloe Vera International Sdn. Bhd. in Selangor.

Preparation of coating solution
The gel matrix was separated from the outer cortex of aloe vera leaves and grinded in a blender. The obtained mixture was then filtered. The aloe vera gel was then boiled at 100°C for 10 minutes. Three different concentrations of aloe vera coating (50, 75 and 100 v/v %) were prepared with an appropriate dilution in water. It was cooled immediately at ambient temperature and stored in amber bottles.

Application of coating solution
All wax apples were washed thoroughly with 200 ppm sodium hypochlorite and dried on clean paper towel. Wax apples for the treatment groups were then dipped in the respective coating solution for 10 minutes, and left for one hour at room temperature to allow the coating material to completely dry. The wax apples were then stored at 10°C for 12 days. Wax apples without any coating were used as the control. All treatments were done in triplicate, and all parameters were measured every three days interval.

Vitamin C content
Standardisation of 2,6- dichloroindophenol (DCIP) was carried out prior to the titration using the wax apple juice. Ascorbic acid standard solution (1 mL) was added into a conical flask which contains of 15 mL of 0.25% oxalic acid and 0.5 mL of 1 N hydrochloric acid, and the solution was mixed well. The wax apple juice solution was titrated with the DCIP until the colour was changed to light pink. The vitamin C concentration was expressed as milligram per 100 millilitre (mg/100mL).

Total anthocyanin
The total anthocyanin content in wax apples was measured using pH differential method. Potassium chloride and hydrochloric acid were used as buffers. Potassium chloride solution was prepared by dissolving 1.49 g of potassium chloride into 100 mL of distilled water. Hydrochloric acid solution was prepared by diluting 1.7 mL of hydrochloric acid in 100 mL of distilled water. pH 1 buffer was prepared by mixing 25 mL of potassium chloride solution with 67 mL of hydrochloric acid solution. An amount of 1.64 g of sodium acetate (CH3COONa) was dissolved in 100 mL of distilled water. Then, using a pH meter, the pH of sodium acetate solution was adjusted to pH 4.5 using the hydrochloric acid solution. Wax apple extract (0.5 mL) was added into two volumetric flask, each containing pH 1 and pH 4.5 buffer solution. The absorbance of wax apple extract was measured at 700 nm. The absorbance was calculated using the formula below:

\[ A = (A \times pH1.0 – 700nm pH1.0) – (A \times pH4.5 – A700nm pH4.5) \]

Total flavonoid content
The total flavonoid content was determined using the aluminum chloride colorimetric assay. An amount of 0.3 mL of sodium nitrite solution (5%) was added to 1 mL of wax apple extract, followed by 0.3 mL of 10% aluminum chloride solution. The test tubes were incubated at ambient temperature for five minutes, and then 2 mL of 1 M sodium hydroxide was added to the mixture. The absorbance was measured at 510 nm. A calibration curve was prepared with catechin and the results were expressed as mg CE/100 g sample.

Weight loss
The wax apples were weighed using electronic weighing balance. The results are expressed as the percentage loss of initial weight:

\[ \text{Weight loss} (%) = \frac{\text{initial weight of sample} – \text{final weight of sample}}{\text{initial weight of sample}} \times 100 \]

Titratable acidity (TA)
Wax apples juice (10ml) was made to 20 mL with distilled water. An aliquot (5 mL) was titrated with 0.1 N NaOH using phenolphthalein as the indicator. TA was expressed as the percentage of citric acid.
**Firmness**

Firmness of wax apple samples was evaluated by using TA.XT Plus Texture Analyser. A 5 mm diameter stainless steel cylindrical probe was used for the penetration test, 5 kg load cell and 2 mm/s test speed with a travel distance of 10 mm.

**Statistical analysis**

Data analysis was carried out using SPSS version 20.0. Differences of mean were tested with one-way analysis of variance (ANOVA) and Tukey test, with a level of significance at \( p < 0.05 \).

**RESULTS AND DISCUSSION**

**Vitamin C content**

The effect of aloe vera gel coating on the vitamin C content in wax apples are shown in Figure 1. All tested wax apples including the control (uncoated) and coated with different concentration of aloe vera gel show a reduction in the content of vitamin C throughout the 12 days of storage period. However, the reduction was observed to be slower in the coated wax apples when compared to the control. Vitamin C in 100% aloe vera coated wax apples was significantly higher (\( p < 0.05 \)) when compared to the control throughout the storage period. Wax apples coated with 75% aloe vera gel also show a higher value of vitamin C than control from day-6 to day-12 of storage (\( p < 0.05 \)). Decrease in the vitamin C content with storage duration is partly attributed to the oxidation of ascorbic acid into dehydroascorbic acid by the ascorbic acid oxidase (Lee & Kader, 2000). From the finding, we observe that aloe vera gel coating is effective in reducing the vitamin C loss in coated wax apples throughout the storage period. This could have been due to the low permeability of aloe vera gel based coating to oxygen which lowers the activity of the enzymes and prevents the oxidation of ascorbic acid. Srinu et al. (2012) reported that fruit coated with aloe vera gel has significantly reduced respiration rate which is a factor for the retention of the vitamin C in fruit. Hassanpour (2015) have also reported retainment of vitamin C level in raspberries coated with the aloe vera gel after eight days of storage at 4°C, which supports the observation of the current study.

**Total anthocyanin content**

Anthocyanin is a natural pigment which is responsible for the colours of fruit and is one of the major classes of flavonoids (Gross, 1987). Total anthocyanin content in tested wax apples shows a decrement with some fluctuations in 50% and 100% aloe vera coated wax apples (Figure 2). Condensation reaction between ascorbic acid and anthocyanins results in degradation of both compounds (González-Molina et al., 2009), which is supported by the observation of decreased vitamin C content. However, wax apples treated with 100% aloe vera coating have a significantly higher anthocyanin (\( p < 0.05 \)) when compared to the control throughout the storage period. Aloe vera coating was observed to be able to delay the decrease of anthocyanin content in the coated fruits. The results obtained are in accordance with the findings from Serrano et al. (2006) and Asghari et al. (2013) in which change of anthocyanin content
was delayed in table grapes coated with aloe vera gel stored at 1°C for 35 days.

**Total flavonoid content**

Flavonoids have been reported to be an effective antioxidant that is essential for health (Moneruzzaman et al., 2011). Reduction of the flavonoid content in stored fruits is therefore a deteriorating factor for the quality of the fruit. The total flavonoid content of wax apples shows a decreasing trend with some fluctuations (Figure 3). Different behaviour of individual flavonoid compounds was previously reported by Piretti et al. (1994) in which catechins were reduced, but cyanidin-7-galactoside, quercetin-3-glycosides and phloridzin remained unchanged in stored apples. In addition, polymerization of flavonoids can occur in fruits stored at cold temperature (Awad & de
Jagger, 2000), which might not be measured by the total flavonoid assay. These might explain the fluctuations of flavonoid content measured in this study.

In this study, consistent decrease in flavonoid content was observed in control wax apples up to day-9 of storage period. The flavonoid content is higher \((p < 0.05)\) in wax apples coated with 50% and 75% aloe vera gel at day-6 of storage when compared to the control. In addition, the decrease of flavonoid was slower in wax apples coated with 100% aloe vera gel, which is supported with the observation of a significantly higher flavonoid at day-9 and day-12 of storage period when compared to the control \((p < 0.05)\). The result is supported by findings of Martínez-Romero et al. (2013) in which ready-to-eat pomegranate arils treated with aloe vera gel exhibited significant retention of bioactive compounds including flavonoids after storage at 3°C for 12 days.

**Weight loss**

All tested wax apples have an increase of weight loss throughout the storage period (Figure 4). This is a normal scenario on which fruit losses moisture through transpiration (Veraverbeke et al., 2003). In this study, we observe that the control wax apples have the highest percentage of weight loss at the end of storage period compared to other treatments with a mean of 2.03%. While, wax apples coated with 100% aloe vera gel have the lowest percentage of weight with a mean of 1.56%. Wax apples coated with aloe vera gel have a tendency for a lower weight loss when compared to control, but no significant difference was observed. The reduction of moisture loss seen in this study may be due to the hygroscopic properties of aloe vera gel which form a water barrier between the fruit and the surrounding that prevent the moisture released into the environment (Misir et al., 2014). Baldwin (1994) suggests that edible coatings conserve the water content in the fruit which prevent the loss of water from the fruit. Loss of water can lead to wilting and shriveling (Ghaouth et al., 1991) which both reduce commodity’s marketability. Edible coatings can offer an effective barrier to oxygen, carbon dioxide and water vapour transmission that help to reduce the weight loss in fresh produce (Tapia et al., 2008). Reduction of weight loss treated with aloe vera gel is also reported in some previous studies (Martínez-Romero et al., 2006; Ahmed et al., 2009; Castillo et al., 2010). The aloe vera gel which is composed of mainly polysaccharide has been reported to be highly effective as a moisture barrier (Ni et al., 2004).

**Titratable acidity (TA)**

The percentage titratable acidity of wax apple increased for all the treatments, but the rate of increase in treated fruits is comparatively slower than the control (Figure 5). The acidity of wax apple fruit is important in imparting taste to the fruit. The predominant acid in ripened wax apple fruit is citric acid. This suggests a slower ripening in the coated fruit when compared to the control. This observation is in accordance to the observation of slower ripening of table grape (Valverde et al., 2005) and sweet cherry (Martínez-Romero et al., 2006) coated with aloe vera gel. Aloe vera has been suggested to modify the internal atmosphere of a fruit which represent similar quality retention as in the application of modified atmosphere packaging (Martínez-Romero et al., 2003).

![Fig. 4. Effect of different concentration of aloe vera gel coating on percentage of weight loss in wax apple. Data are presented as mean ± standard deviation.](image-url)
Fig. 5. Effect of different concentration of aloe vera gel coating on titratable acidity in wax apple. Data are presented as mean ± standard deviation, * indicate significant difference at $p < 0.05$.

Fig. 6. Effect of different concentration of aloe vera gel coating on firmness of wax apple. Data are presented as mean ± standard deviation.

**Firmness**

Fruit firmness is an important quality attribute and is related to the enhancement of storability potential and stimulates a greater resistance to decay, mechanical damage, and the consumer’s acceptability. This study reports a trend of decreased firmness for both aloe vera coated and control wax apples throughout the storage period (Figure 6). There is a slightly higher value of firmness in wax apples coated with 100% aloe vera gel, but no significant difference was observed between the aloe vera coated and the control wax apples. This result contradicts with the previous finding in which aloe vera is found efficient in maintaining the texture of nectarines (Ahmed et al., 2009) and sweet cherries (Martínez-Romero et al., 2006). This difference may be due to the varied cell wall composition among the different fruits that influence distinct activities of cell wall hydrolytic enzymes such as pectinases in fruit softening (Moneruzzaman et al., 2016).
CONCLUSION

Aloe vera gel coating is shown to help retaining the vitamin C, anthocyanin, and flavonoid content in wax apples. The gel at the concentration of 100% was the most effective in retaining these bioactive compounds in wax apples throughout 12 days of storage period at 10°C. Aloe vera gel (100%) shows a tendency for the reduced weight loss and delayed increase of titratable acidity. However, aloe vera does not show any improvement of firmness of the fruit. Aloe vera gel coating can be an alternative to postharvest chemical treatments to maintain the postharvest quality of wax apples and improve its storage life. This study can be advanced towards exploring the antifungal effect of aloe vera gel coating on harvested wax apples. Further improvement can be made by adding the essential oil as an added antifungal value to inhibit the postharvest diseases in this fruit.

ACKNOWLEDGEMENT

The authors acknowledge the support of funding from School of Food Science and Technology, Universiti Malaysia Terengganu.

REFERENCES


Hassanpour, H. 2015. Effect of Aloe vera gel coating on antioxidant capacity, antioxidant enzyme activities and decay in raspberry fruit. LWT-Food Science and Technology, 60(1): 495-501.


