

Full Length Research Paper

Effect of *Aloe vera* gel coating on postharvest quality and shelf life of mango (*Mangifera indica* L.) fruits Var. 'Ngowe'

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Mango is a highly perishable fruit and high post-harvest losses occur in Africa. In order to address this problem, 4 concentrations of *Aloe vera* gel (AG) (0, 25, 50 and 75%) and chitosan (1%) were tested at two temperature levels (room temperature 15-22°C and 13°C) to determine their effect on the postharvest life of mango (var.'Ngowe'). The experimental design was a 5 by 2 factorial experiment embedded in a complete randomized design with three replications. Data were recorded on titratable acidity, fruit colour, ascorbic acid and anthracnose disease incidence. The results showed that at both temperatures 50 and 75% *Aloe* concentrations significantly increased the shelf life evidenced by reduced decrease in titratable acidity. Fruit colour and ascorbic acid were also maintained for longer periods in these treatments. Findings of this study demonstrate the potential of using *Aloe vera* gel at 50% as a coating for improved postharvest shelf life and maintaining quality of mango fruits hence reduced postharvest losses.

Key words: *Aloe vera* gel, postharvest shelf life, mango.

INTRODUCTION

Mango (*Mangifera indica* L.) is the most economically important fruit of the Anacardiaceae family (Tharanathan et al., 2006). World trade in mangoes has been increasing over the years, and both exports from Kenya and local consumption is growing. The world market continues to become more price-competitive in spite of postharvest challenges e.g. losses caused by diseases (HCDA, 2011). Mango is one of the most popular fruits all over the world as it has an attractive color, delicious taste and excellent nutritional properties. However, mango fruits are climacteric and ripen rapidly after harvest, this limits their storage, handling and transport potential

(Lalel et al., 2003).

Mango is an easy access to post-harvest disease infection and production and consumption imbalances after harvesting lead to considerable losses (Zeng et al., 2006). Therefore, scientists are working towards prolonging the shelf life of the fruit by slowing down the ripening process while maintaining quality and flavor. Fruit coating after harvesting is becoming popular in this respect (Gill et al., 2005). However, possible health risks associated with the residue of the coating materials like fungicides are reducing the scope of coatings. Edible coatings have no residue associated risks and are

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possible alternative options (Ergun and Satici, 2012).

The use of *Aloe vera* gel has drawn interest in the food industry (Arowora et al., 2013). *A. vera* based edible coatings have been shown to prevent loss of moisture and firmness, control respiration rate and development and maturation, delay oxidative browning, and reduce microorganism proliferation in fruits such as sweet cherry, table grapes and nectarines (Valverde et al., 2005; Matinez-Romero et al., 2005; Ahmed et al., 2009). In addition to the traditional role of edible coatings as a barrier to water loss and delaying fruit senescence, the new generation coatings are being designed for incorporation and/or for controlled release of antioxidants, nutraceuticals, chemical additives and natural antimicrobial agents. It has also been reported that *A. vera* extracts possess antimicrobial activity against gram positive and gram negative bacterial pathogens (Adetunji, 2008).

The use of *A. vera* gel as an edible surface coating has been reported to prolong the shelf life and to delay changes in parameters related to deterioration of quality in sweet cherry and table grapes (Martinez- Romero et al., 2006; Serrano et al., 2006), yet no studies have demonstrated the use of *A. vera* natural plant extract based on its antifungal properties on enhancement of shelf life and quality of mango fruits. Therefore, this study was conducted with the objective of evaluating the effects of the different *A. vera* gel on postharvest life of mango fruits.

MATERIALS AND METHODS

Research site

The postharvest study was carried out in a laboratory at Egerton University, Njoro, Kenya. The laboratory lies at a latitude of 0° 23' South, longitude 35° 35' East, altitude of approximately 2,238 m a.s.l in the Lower Highland 3 (LH3) agroecological zone (Jaetzold and Schmidt, 1983). The laboratory records average maximum and minimum temperatures of 19 to 22°C and 5 to 8°C, respectively (Egerton Metrological Station, 2009).

Materials

Mango

The variety 'Ngowe' was used. 'Ngowe' is a popular mango variety in Kenya, which has little fibre and has excellent eating quality but it is susceptible to anthracnose. All the fruits that were used in this study were acquired from a grower in Masii in Machakos County, Kenya. The fruits were harvested at the mature green stage having no visible blemish. The fruits were transported to the laboratory on the same day.

Aloe vera

Leaves of *A. vera* were harvested from Lare in Nakuru County, Kenya. Only the fully extended mature leaves were harvested. The leaves were then stored in plastic papers and transported to the laboratory within same day.

Chitosan

Crushed chitosan powder food grade was purchased from Kobian Chemicals Company, Nairobi.

Preparation of coating solutions

Aloe gel was obtained from fresh aloe leaves, the matrix was separated from the outer cortex of the leaves and the colourless hydroparenchyma homogenized in a blender. The resulting mixture was filtered using Whatman filter paper number 100 to remove the fibres. The liquid constituted fresh *A. vera* gel. The gel matrix was pasteurized at 70°C for 45 min. For stabilizing, the gel was cooled immediately to an ambient temperature and 4.5 g of ascorbic acid was added; 4.5 g of citric acid was then added to adjust the pH to 4. To prepare chitosan coating, 1% Chitosan (Kobian Chemical Co.) was dissolved in a 0.5% glacial acetic acid and distilled water. The pH value of the chitosan solution was then adjusted to 5.6 using 0.1 M NaOH.

Application of treatments and experimental design

The coating solutions were: aloe gel (0%) as a negative control, aloe gel (25%), aloe gel (50%), aloe gel (75%), and chitosan (1%) as a positive control. Fresh fruits were dipped completely into the coatings solutions at room temperature for 25 min. The fruits were allowed to drain and then dried at room temperature to allow a thin film layer to be formed on the fruits. The fruits were then stored at room temperature and at 13°C. Mature, green fruits, without any visible blemish, were selected and the pedicels were removed. The fruits were then randomly divided into eight lots of twenty fruits each. The first lot constituted the positive control and was coated with chitosan. The second, third, fourth and fifth lots were coated by dipping completely in *A. vera* gel at concentrations of 0, 25, 50 and 75% respectively and stored at room temperature and at 13°C. The experiment was laid out as a 5 by 2 factorial experiment embedded in a completely randomized design with three replications. Various parameters were evaluated at 4 day intervals until the overall acceptability became unsatisfactory for each lot of samples (the fruit was considered as waste when it is infected by disease).

Titration acidity (TA)

TA was determined by titrating 100 ml of juice against sodium hydroxide having concentration of 0.1 N (AOAC 2000) and expressed as the percentage of citric acid per 100 g fresh mass. Individual mango fruit from each treatment was ground in a blender to obtain freshly prepared juice which was then filtered using filter papers.

Colour

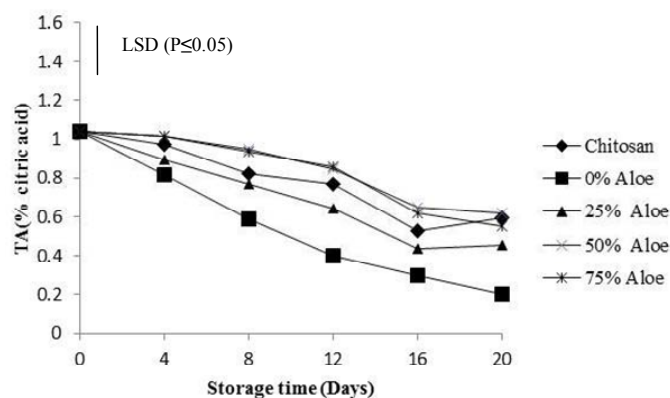
Peel color was measured at the equator on opposite cheeks of the fruit. Flesh color was measured in the center of one cut cheek. Both peel and flesh colours were measured using portable whiteness colourimeter (WSD-3 TYPE). Measurements were recorded using standard Hunter L a b chromatic system and were expressed as lightness (L), greenness (-a), redness (+a) yellowness (+b), blueness (-b) colour space coordinates. The instrument was calibrated with a standard white ceramic tile and black tile and set up for D65 as illuminate and a 10° observer angle.

Vitamin C content

This was determined by titrating 10 g of mixed pulp sample against

Table 1. Effect of *Aloe vera* gel on Anthracnose severity and anthracnose disease incidents.

Treatment	Severity index		Anthracnose incidence (%)
	% skin area	scores	
Chitosan	12.5 ^a	2	45
0% Aloe	63.6 ^a	4	93
25% Aloe	57.1 ^a	4	80
50% Aloe	50.0 ^a	3	73
75% Aloe	45.6 ^a	3	60

**Figure 1.** Titratable acidity of mango fruits var. 'Ngowe' as affected by *A. vera* gel coatings

the standard 2, 6 dichlorophenol dyes following the procedure outlined in AOAC (2000).

Degree and rate of anthracnose incidents

Anthracnose severity was assessed by measuring the diameter of anthracnose lesions on mango fruits and ranked by use of scale 1–5 where 1=0% of fruit surface rotten, 2=1–25%, 3=26–50%, 4=51–75% and 5=76–100%)

Data analysis

The data collected was subjected to Analysis of Variance (ANOVA) at $P \leq 0.05$, using PROC GLM code of SAS (version 9, 2005) and means for significant treatments separated using the Tukey's Honestly Significant Different Test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Titratable acidity

Mango fruits with coating presented a statistically higher titratable acidity (TA) during storage in spite of the slight decrease observed (Figure 1). TA increased during storage in all treatments but the rate of increase in treated fruits was comparatively slower compared to the control. At day zero there was no significant difference

($P \leq 0.05$) between the treatments (Table 1). The initial TA was 1.04% citric acid. In day four, fruits coated with 50 and 75% *A. vera* gel concentration had a significantly lower TA value compared with those coated with 0% *A. vera* gel.

On day-8, fruits coated with 50% *A. vera* gel had a significantly lower TA values compared with those coated with other fruit coating treatments. On day-12, the highest TA was observed in fruits coated with 75% *A. vera* gel and the lowest readings were recorded for fruits coated with 0% *A. vera* gel. At day sixteen of the storage period, the highest TA was observed on fruits coated with 50% *A. vera* gel and the lowest readings were recorded for fruits coated with 0% *A. vera* gel. At day at the end of storage period (twenty days), fruits coated with 50% *A. vera* gel had the highest TA while the control had the lowest TA value.

Generally TA was maintained for those fruits coated with 50 and 75% *A. vera* gel. TA decreased gradually in all treatments but the rate was slower in treated fruits compared to negative control. There was a lower decrease in the titratable acidity for *A. vera* and chitosan coated mangoes. *A. vera* gel and chitosan coating must have modified internal atmosphere thus reducing ripening and maintenance of the TA (Nabigol and Asghari, 2013). Reduction in TA for uncoated fruits is due to conversion of acids into sugars and their further utilization in the metabolic processes of the fruit. Doreyappa and Huddar (2001) reported the similar pattern in different varieties of mango fruits stored at 18 to 34°C. They observed a series of physico-chemical changes during ripening and the major changes were decrease in acidity. The acidity of the fruit is an important character to determine its quality and acceptability. Very high or very low values of the acidity are not recommended for good fruit.

Fruit colour

The coatings were effective on peel colour change of the mangoes stored under room temperature conditions and 13°C (colour change during ripening for this variety of mango is from green to yellow). Color changes in peel are presented as L^* , a^* , b^* and were expressed as lightness (L^*), greenness ($-a^*$), yellowness ($+b^*$), colour space coordinates. Fruits from each treatment for both

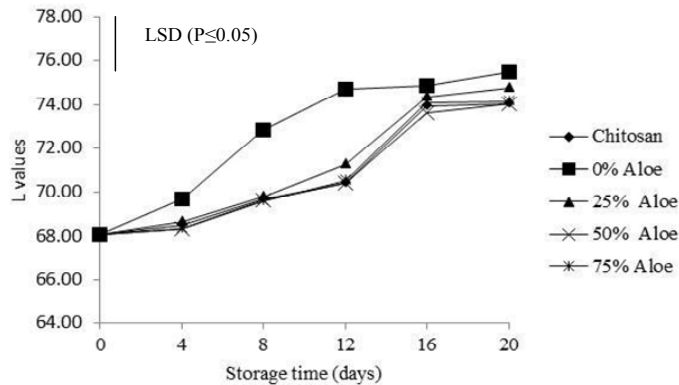


Figure 2. Effect of different *A. vera* gel concentrations on L^* value of the peel colour of mango fruits var. 'Ngowe'.

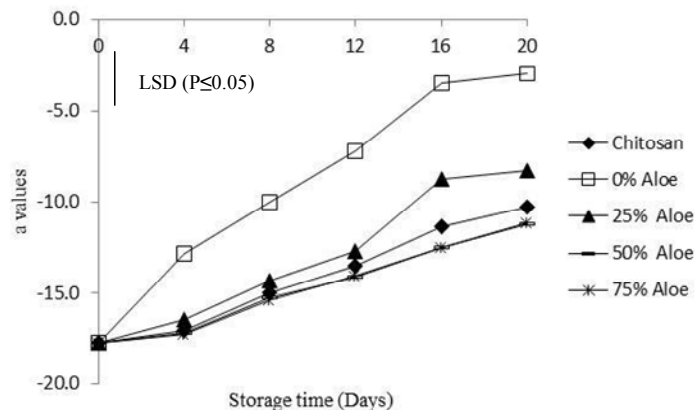


Figure 3. Effect of different *Aloe vera* gel concentrations on Chromatic a^* of the peel color of mango fruits var. 'Ngowe'.

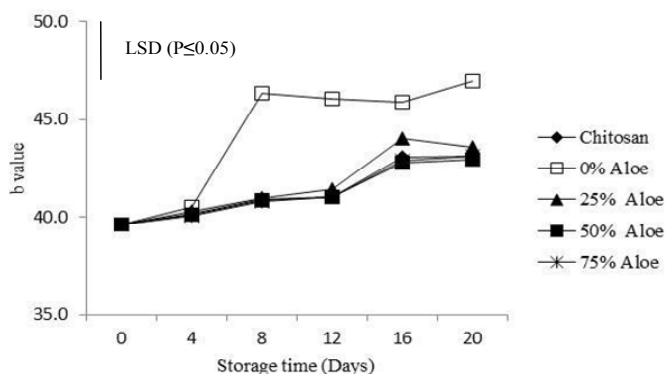


Figure 4. Effect of different *Aloe vera* gel concentrations on Chromatic b^* of the peel color of mango fruits var. 'Ngowe'.

trials registered some changes in chromatic L^* , a^* and b^* colour values during the storage period (Figures 2, 3 and 4 respectively).

Lightness (L^*) increased significantly ($P \leq 0.05$) during storage, changes in L^* value for control (L^* values increased from 68.1 to 75.5) which was higher than what was recorded in the coated fruits (Figure 2). L^* values increased over time irrespective of the coatings from 68.1 to 75.5 for negative control, from 68.1 to 74.8 for fruits coated with 25% *A. vera* gel, from 68.1 to 74.0 for 50% *A. vera* gel coated fruits, from 68.1 to 74.1 for 75% *A. vera* gel coated fruits and from 68.1 to 74.0 for chitosan coated fruits while no significant difference ($P \leq 0.05$) were recorded for chitosan and 50% *A. vera* gel coated treatments at the end of the storage period.

Chromatic a^* value from mango fruits also increased over time irrespective of the treatments. There was a gradual significant increase ($P \leq 0.05$) in peel a^* value beginning on day eight (Figure 3). Before the storage, the a^* value was -17.7, and after the storage the value reached to -2.9 for negative control fruits, to -8.3 for 25% *A. vera* gel coated fruits, to -11.2 for 50% *A. vera* gel coated fruits, -11.2 for 75% *A. vera* gel coated fruits and to -10.3 for chitosan coated fruits. The increase in a^* value was however, slower for fruit coated with 50 and 75% *A. vera* compared to control or 25% *A. vera* gel treatments.

Chromatic b^* value similar to L^* and a^* value for fruits slightly increased over time regardless of the coatings, and it was significantly higher ($P \leq 0.05$) on day eight for the negative control (Figure 4). Initial b^* value was 39.6, afterwards the value gradually increased, reaching to 46.9 for negative control fruit, to 43.5 for 25% *A. vera* gel coated fruits, to 42.9 for 50% *A. vera* gel coated fruits, 43.1 for 75% *A. vera* gel coated fruits and to 43.1 for chitosan coated fruits. The increase in a^* value was however, slower in fruits coated with 50 and 75% *A. vera* gel and chitosan compared to negative control.

Generally the peel color of the mango fruits coated with 50 and 75% *A. vera* gel was significantly less developed than those coated with other treatments. The coatings were effective on flesh colour change of the mangoes under room temperature conditions and 13°C (colour change during ripening for this variety 'Ngowe' is from green to yellow). Color changes in peel are presented as L^* , a^* , b^* and were expressed as lightness (L), greenness ($-a$), blueness ($+a$), yellowness ($+b$), colour space coordinates. Fruits from each treatment for both trials registered some changes in chromatic L^* , a^* and b^* colour values during the storage period (Figures 5, 6 and 7 respectively).

The L^* (lightness) decreased during storage, L^* values for control decreased from 88.1 to 72.5 which was lower than the coated fruits (Figure 5). L^* values decreased over time irrespective of the treatments from 88.1 to 72.5 for negative control, from 88.1 to 75.8 for 25% *A. vera* gel coated fruit, 76.0 for 50% *A. vera* gel coated fruits, 76.6 for 75% *A. vera* gel coated fruits and 76.0 for chitosan coated fruits. There was no significant difference ($P \leq 0.05$) between fruits coated with chitosan and 50% *A.*

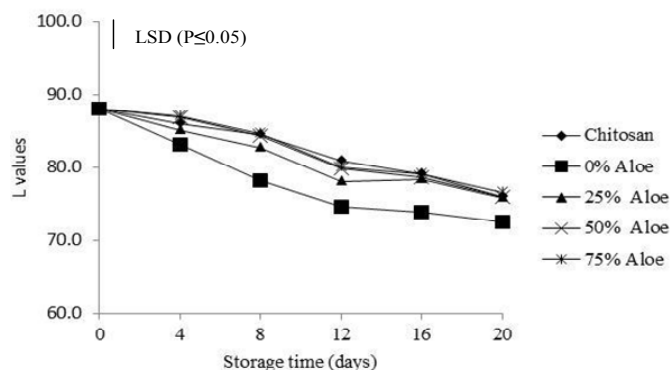


Figure 5. Effect of different *Aloe vera* gel concentrations on Chromatic L* value of the flesh color of mango fruits var. 'Ngowe'.

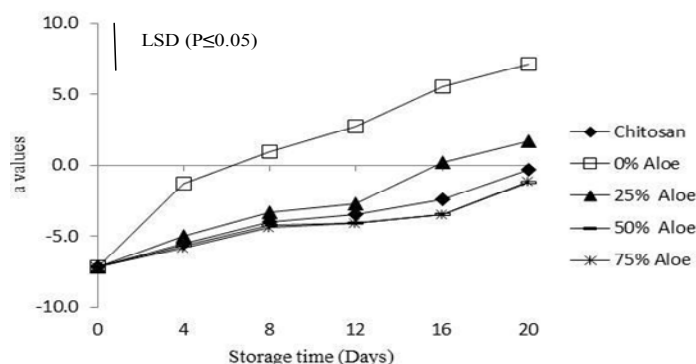


Figure 6. Effect of different *Aloe vera* gel concentrations on Chromatic a* of the flesh color of mango fruits.

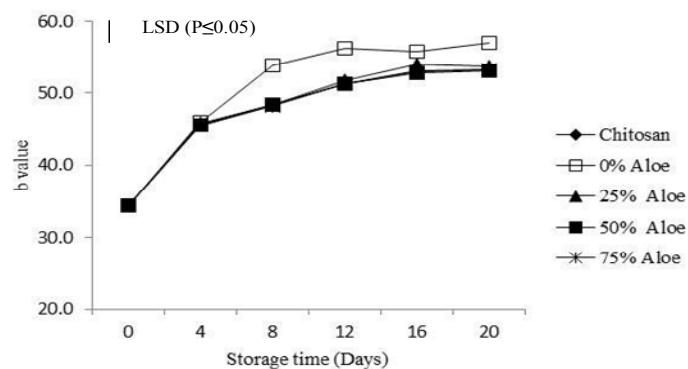


Figure 7. Effect of different *Aloe vera* gel concentrations on Chromatic b* of the flesh color of mango fruits var. 'Ngowe'.

vera gel coated treatments at the end of the storage period.

Chromatic a* value from mango fruits also increased over time irrespective of the treatments. There was a gradual increase in flesh a* value beginning on day eight

(Figure 6). Before storage, a* value was -7.2, and after the storage the value increased to 7.1 for negative control fruits. It also increased to 1.7 for fruits coated with 25% *A. vera* gel, -1.2 for fruits coated with 50% *A. vera* gel, -1.2 for 75% *A. vera* gel coated fruits and to -0.3 for chitosan coated fruit. The increase in a* value was however, slower for fruit coated with 50 and 75% *A. vera* compared to negative control or 25% *A. vera* gel treatments. There was a significant difference ($P \leq 0.05$) among the treatments at the end of the storage period.

Chromatic b* value gradually increased over time regardless of the treatments, and it was significantly higher ($P \leq 0.05$) on day eight for fruits coated with 0% *A. vera* gel (Figure 8). Initial b* value was 34.4 and it gradually increased, reaching to 57.0 for fruits coated with 0% *A. vera* gel, to 53.6 for 25%, to 53.0 for 50%, 53.2 for 75% *A. vera* gel and to 53.2 for chitosan coated fruits. The increase in b* value was however, slower for fruit coated with 50 and 75% *A. vera* and chitosan compared to 0% *A. vera* gel. There was a significant difference ($P \leq 0.05$) among the treatments at the end of the storage period.

Generally the flesh color of the mango fruits coated with 50 and 75% *A. vera* treatments was significantly less developed than flesh colours in the other treatments. Color is related to the presence of different pigments. Changes in colour are mainly due to chlorophyll transformation into other pigments and to the synthesis of carotenoids and anthocyanins. Chlorophyll retention was higher in the fruits coated with *A. vera* gel and chitosan coatings and least of it was seen in the uncoated fruit. *A. vera* gel treatment and chitosan delayed the green colour loss on the fruit skin. Coatings applied to fruit act as a barrier, altering permeability to gases. This results in increased internal CO₂ contents, slowing down the external and internal colour change of the fruit in return delaying chlorophyll degradation and carotenoid synthesis (Ergun and Satici, 2012). Similar results of colour retention in coated fruit had been reported in carambola fruits (Neeta et al., 2013).

Ascorbic acid

The ascorbic acid content in the mango fruits decreased significantly during the ripening storage period (Fig.8). A significant decrease ($P \leq 0.05$) in ascorbic acid contents was observed in all the treatments. Initially, the ascorbic acid was 26.6 mg/100 g. At day four, there was significant difference ($P \leq 0.05$) between the negative control (0% *A. vera* gel) and the other treatments but there was no significant difference among 50 and 75% *A. vera* gel concentrations and those coated with 1% chitosan (the positive control). At day eight, 50% *A. vera* gel was the most effective in reducing decrease in ascorbic acid followed by chitosan while the 0% aloe had the least ascorbic acid. At day twelve, there was

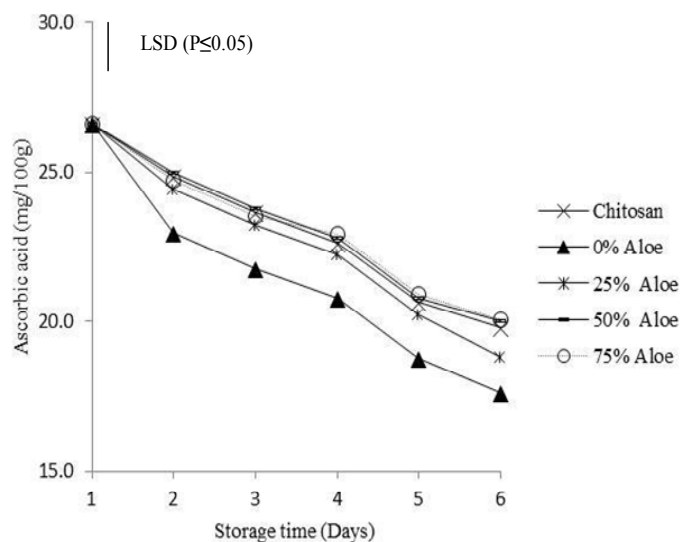


Figure 8. Ascorbic acid of mango fruits var. 'Ngowe' as affected by *Aloe vera* gel coatings.

significant difference between the control and the rest of the treatments, 75% *A. vera* gel had the highest ascorbic acid.

At day sixteen, there were significant effects between the control and the other treatments 25, 50 and 75% *A. vera* gel and chitosan treatments. The negative control had the lowest ascorbic acid while 75% *A. vera* gel had the highest ascorbic acid value. At day twenty, 0% *A. vera* gel had the lowest ascorbic acid while 75% *A. vera* gel had the highest ascorbic acid among the other treatments. Generally, all treatments had a decrease in ascorbic acid from the initial value. There was a gradual decrease in all days although the decrease was reduced by *A. vera* treatments. Ascorbic acid is one of the most abundant antioxidants present in fruits. Results suggest that *A. vera* gel and chitosan coating caused lower losses of antioxidant capacity by the end of storage, when coated fruits were compared to the negative control. Application of *A. vera* gel and chitosan modified internal atmosphere, more concentration of CO₂ resulting to lower concentration of O₂ hence the oxidation process was retarded which caused reduction in conversion of ascorbic acid to dehydro ascorbic acid. Lal et al. (2003) reported similar results on mango using various chemicals under different storage period.

Anthracnose incidence

None of the *A. vera* gel concentration tested inhibited the growth of *Colletotrichum gloeosporioides* as compared to the control, and grew almost similarly with all treatments through the 7-day incubation period. Mango fruits treated with 1% chitosan had the lowest disease severity index.

The highest fungicidal effect was observed in those mangoes coated with 1% chitosan.

Conclusion AND Recommendation

Findings of this study demonstrate the potential of using *A. vera* gel as a coating for improved postharvest shelf life and maintaining quality of mango fruits hence reduced postharvest losses. The results showed that at both temperatures, 50 and 75% aloe concentrations significantly increased the shelf life evidenced by reduced decrease in titratable acidity. Fruit colour and ascorbic acid were also maintained for twenty days in these treatments. Since *A. vera* is an edible plant, does not pose any environmental hazard and is easily available in Kenya and other tropical regions, *A. vera* at 50% concentration can be used as an alternative fruit coating for mangoes.

Conflict of Interest

The authors have not declared any conflict of interest.

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