

Full Length Research Paper

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

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Mango (*Mangifera indica* L.) is a popular and economically important tropical fruit throughout the world due to its excellent nutritional composition, eating and visual qualities. However, the fruit is highly perishable and as a result high post-harvest losses continue to be reported especially in Africa. In order to address this problem, four concentrations of *Aloe vera* (AG) (0, 25, 50 and 75%) and chitosan (1%) were tested at two temperature levels (room temperature 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 weight loss, pH and total soluble solids (TSS) among others. The results show that at both temperatures 50 and 75% aloe concentrations significantly increased the shelf life evidenced by reduced percentage weight loss. Fruit firmness and total soluble solids concentration and pH were also maintained for longer periods in these treatments. Findings of this study demonstrate the potential of using *A. 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 fruit quality.

INTRODUCTION

Mango (*Mangifera indica* L.) is the most economically important fruit in 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 for example, 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 has 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

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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 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 micro-organism 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 (Vargas et al., 2008). 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* concentrations 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).

Mango

The variety 'Ngowe' was used: it is popular, 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. The mature green fruits were without any visible blemish. The fruits were transported to the laboratory 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 vera 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 Watman 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 20 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 (recommended optimum storage temperature for mangoes). 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 and/or its firmness value is less than 2).

Weight loss

Three fruits in each replication for each treatment were marked before storage, and weighed using a digital balance (EK-600H, Japan). The same fruits were weighed at the beginning of the experiment and at the end of each storage period. The results were expressed as percentage loss of initial weight.

Total soluble solid (TSS)

Total soluble solids were determined using hand held refractometer (0-30 °Brix) (RHW refractometer, Optoelectronic Technology Company Ltd. UK). Individual mango fruits from each treatment were ground in a blender to obtain soluble solids readings from the freshly prepared juice.

Firmness

Three mango fruits from each treatment were used to determine

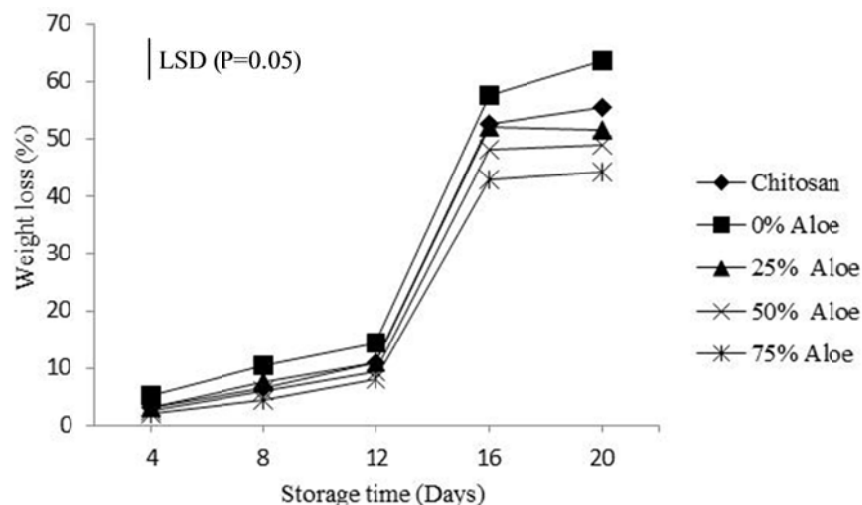


Figure 1. Percentage weight loss in Ngowe mango fruits treated with different concentrations of *Aloe vera* coatings and chitosan as a positive control.

fruit firmness using a hand held penetrometer (model 62/DR, UK) with a 8 mm diameter probe. The results were reported in Kg Force.

pH

This was measured with a standard calibrated pH meter (ADWA CO.). This measurement was made on juice expressed from flesh of the whole fruit filtered through filter papers.

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

Weight loss

Fruits from all the treatments lost weight throughout the entire storage period (Figure 1). 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 25, 50 and 75% *A. vera* gel concentrations and those coated with 1% chitosan (the positive control). At day eight, 75% *A. vera* gel was the most effective in reducing weight loss followed by 50% while the 0% aloe had the highest weight loss. At day twelve, there was significant difference between the control and 50 and 75% *A. vera* gel treatments. Seventy five percent *A. vera* gel had the lowest weight loss.

At day sixteen, there were significant effects between the control and 25, 50 and 75% *A. vera* gel treatments. The negative control had the highest weight loss though it

was not significantly different from Chitosan. At day twenty, 0% *A. vera* gel had the highest weight loss while 75% *A. vera* gel had the lowest weight loss among the other treatments. Generally weight loss was lowest in day four, eight and twelve with a sharp increase between day twelve and sixteen. After day sixteen, weight loss was highest only in the 0% *A. vera* treatments.

Fruits treated with 0% *A. vera* gel as a control recorded the highest weight loss compared to those treated with 25, 50, 75% aloe concentrations and those coated with 1% chitosan as a positive control. It was observed that the average weight loss of mango fruits significantly increased with increasing storage period. Fruit weight loss occurs as a result of dehydration and loss of water from fruit surface. *A. vera* gel must have created a semi-permeable barrier to gases and water vapor and therefore reduced water loss and hence reduced weight loss. Similar to the present results, *A. vera* gel reduced weight loss in 'Arctic Snow' nectarines (treated with 2.50%, stored at 20°C (Ahmed et al.(2009), 'StarKing' cherries (treated with 33%, stored at 1°C; Martinez-Romero et al., 2006) and 'Autumn Royal' table grapes (treated with 33%, stored at 2°C; Castillo et al., 2010).

Fruit firmness

There was a decreasing trend in fruit firmness with storage time in both coated and uncoated mangoes during the course of storage (Figure 2). Initially there was no significant difference ($P \leq 0.05$) between the treatments. At day four of the storage period, 50 and 75% *A. vera* gel coated fruits had the highest firmness value while the lowest values were observed in fruits coated with 0% *A. vera* gel. At day eight, fruits treated with 0% *A. vera* gel had the lowest value of firmness while 75% *A. vera* gel

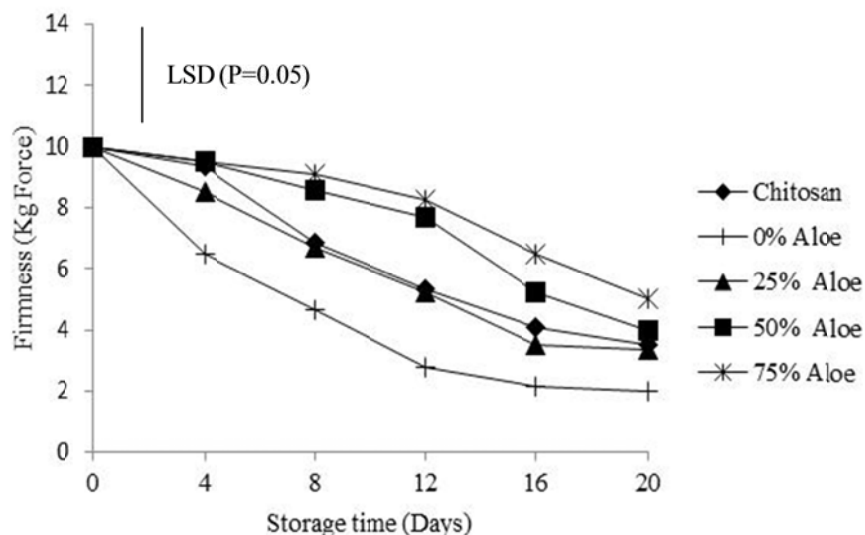


Figure 2. Fruit firmness of Ngowe mango fruits treated with different concentrations of *Aloe vera* coatings and chitosan as a positive control.

had the highest value of firmness. At day twelve, there were significant differences among the treatments, 0% *A. vera* gel had the lowest fruit firmness value while 75% *A. vera* gel had the highest value. At day sixteen, similar observations as to day twelve were made and at the end of the storage period (twenty days), 0% *A. vera* gel had the lowest fruit firmness value while those coated with 75% *A. vera* gel had the highest value.

It was therefore apparent that the reduced loss in firmness in fruits coated with *A. vera* was due to the effect of the coating which delayed the softening. *A. vera* gel must have modified the internal gas composition of mangoes causing reduction of cell wall degrading-enzymes responsible for mango softening (Aguiar et al., 2011). These results demonstrated beneficial effects of the *A. vera* coating on enhancement of the mango shelf life, since it has been postulated that softening and texture changes during mango fruit ripening determine fruit storability and shelf life, as well as reduced incidences on decay and less susceptibility to mechanical damage. The present study demonstrates observations similar to those of Arowora et al. (2013) who worked on oranges coated with *A. vera* gel. It was, also, observed that fruit firmness significantly decreased with increasing storage period. Loss in fruit firmness with the progress of storage period is due mainly to decomposition, enzymatic degradation of insoluble protopectins to simpler soluble pectins, solubilization of cell and cell wall contents as a result of the increase in pectin esterase activity and subsequent development of juiciness and the loss in peel and pulp firmness.

pH

The pH of the mangoes was observed to gradually increase

during the course of storage (Figure 3). Initially there was no significant difference ($P \leq 0.05$) but at day four, there was significant difference between the treatments. Fruits coated with 50 and 75% *A. vera* and chitosan had the lowest juice pH readings while 0% *A. vera* gel had the highest juice pH readings. At day eight, fruits treated with 75% *A. vera* gel had the lowest pH value and 0% *A. vera* gel had the highest pH reading. At day 12, fruits coated with 50 and 75% *A. vera* gel had the lowest pH reading while the control (0% *A. vera* gel) had the highest juice pH value. For day 16, fruits coated with 50% *A. vera* gel had the lowest pH value and 0% *A. vera* gel coated fruits had the highest pH value.

However, in day 16 there was no significant difference between chitosan coated fruits and 50% *A. vera* gel. At day twenty, it was found that 0% *A. vera* gel had the highest pH value while those coated with 50% *A. vera* gel had the lowest pH value. It was found that *A. vera* coated mangoes had lower pH values at the end of storage period with fruits treated with 75% aloe having the lowest readings; this was due to the semi-permeability created by *A. vera* coatings on the surface of the fruit, which modified the internal atmosphere that is endogenous O_2 and CO_2 concentrations in the fruit, thus retarding ripening. Baldwin et al. (1999) reported similar results using Nature Seal (NS) and Tropical Fruit Coating 213 (TFC) coatings on mango ripening during storage. Similar results were reported in carambola fruits (Neeta et al., 2013).

Total soluble solid (TSS)

Fruits treated with aloe gel and those treated with chitosan had a significantly lower TSS values compared with those treated with 0% aloe concentration (Figure 4).

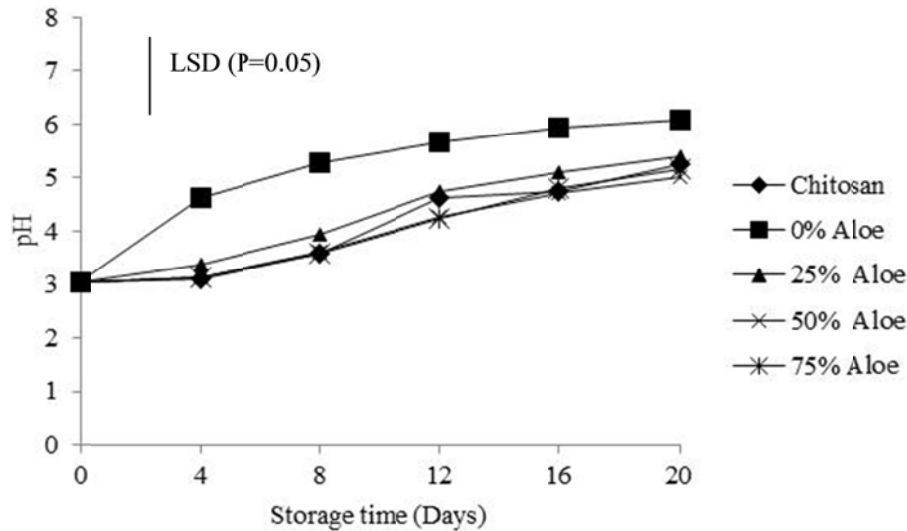


Figure 3. pH of Ngowe mango fruits treated with different concentrations of *Aloe vera* coatings and chitosan as a positive control.

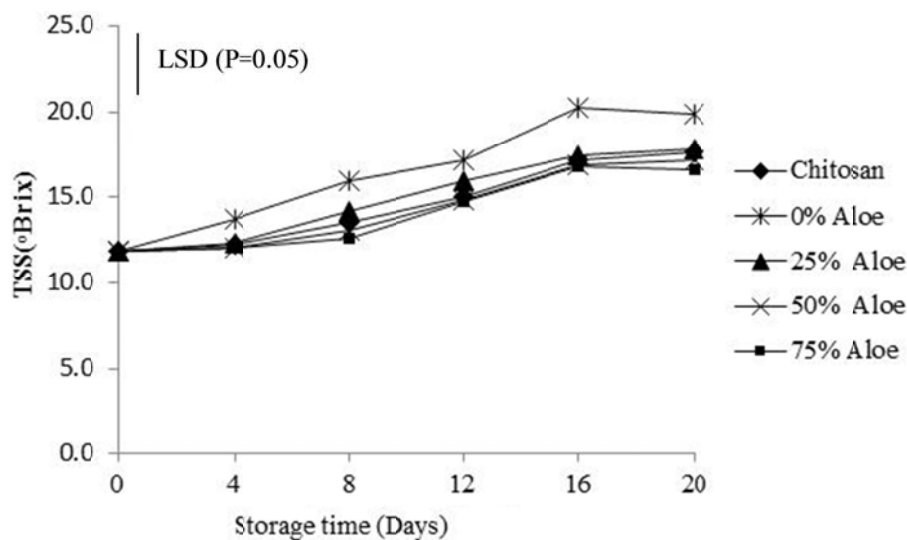


Figure 4. TSS of Ngowe mango fruits treated with different concentrations of *Aloe vera* coatings and chitosan as a positive control.

At day zero there was no significant difference ($P \leq 0.05$) between the treatments. In day four, fruits coated with 25, 50 and 75%, *A. vera* gel concentrations and those coated with chitosan had a significantly lower total soluble solids (TSS) compared with those treated with 0% *A. vera* gel. However there were no significant differences among fruits coated with 25, 50 and 75% *A. vera* treatments and chitosan. In day eight, similar observations were as those of day four.

At day 12, the highest total soluble solids were observed on fruits coated with 0% *A. vera* gel and the lowest readings

were recorded for fruits coated with 75% *A. vera*. At day sixteen of the storage period, the highest TSS was observed on fruits coated with 0% *A. vera* gel and the lowest readings were recorded for fruits coated with 75% *A. vera* gel. At day at the end of storage period (twenty days), fruits coated with 50 and 75% *A. vera* gel had the lowest TSS while the control had the highest TSS. *A. vera* gel and chitosan coatings must have modified internal atmosphere resulting in high CO_2 which retards conversion of starch to sugars and less moisture loss thus reducing ripening and maintaining the TSS.

It was also observed that TSS significantly increased with storage time. This behavior of TSS was likely due to losses in water through respiration and evaporation and hydrolysis of starch during storage and hence increases in TSS (Eman et al., 2013). Ahmed et al. (2009) observed the formation of soluble pectinic acid from insoluble protopectin during senescence of fruit; and they attributed such increase in TSS to the conversion of starch into sugar. Similar results were obtained using *A. vera* gel treatment (2.5%) which suppressed the increase in TSS for 'Artic Snow' nectarines during ripening at 20°C (Ahmed et al., 2009).

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 percentage weight loss. Fruit firmness and total soluble solids concentration and pH were also maintained for longer periods 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 Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

- Aguiar RP, Miranda MR, Lima AM, Mosca JL, Moreira RA, Enéas-Filho J (2011). Effect of a galactomannan coating on mango postharvest physicochemical quality parameters and physiology. *Fruits* 66:269-278.
- Arowora KA, Williams JO, Adetunji CO, Fawole OB, Afolayan SS, Olaleye OO, Adetunji J, Ogundele BA (2013). Effects of *Aloe Vera* Coatings on Quality Characteristics of Oranges Stored Under Cold Storage. *Greener J. Agric. Sci.* 3:39-47.
- Baldwin EA, Burns JK, Kazokas W, Brecht JK, Hagenmaier RD, Bender RJ, Pesis E (1999). Effect of two coatings with different permeability characteristics on mango (*Mangifera indica*, L.) ripening during storage. *Postharvest Biol. Technol.* 17:215-226.
- Eman AA, Ahmed AZ, Ayman ES (2013). Role of some postharvest treatments in maintaining mango fruit quality during cold storage. *J. Appl. Sci. Res.* 9(3):2355-2366.
- Ergun M, Satici F (2012). Use of *Aloe Vera* Gel as Biopreservative for "Granny Smith" and "Red Chief" Apples. *J. Anim. Plant Sci.* 22(2): 363-368.
- Gill PS, Singh NP, Jawandha SK (2005). Proceedings: International Conference on Mango and Date Palm. *Cult. Export* 20:157-166.
- HCD (2011). Horticultural Crops Development Authority. 6:1-8.
- Lalel HJD, Singh Z, Chye S (2003). Aroma volatiles production during fruit ripening of "Kensington Pride". *Mango* 27.
- Neeta BG, Manu LC, Rao TR (2013). Effect of edible coatings on quality and shelf life of carambola (*Averrhoa carambola* L.) fruit during storage. *J. Food Sci. Technol.* DOI: 10.1007/s13197-013-0988-9
- Tharanathan RN, Yashoda HM, Prabha TN (2006). Mango (*Mangifera indica* L.), "The King of Fruits" - An Overview. *Mango (Mangifera indica L.)*. Food Rev. Int. 37-41.
- Zeng KF, Cao JK, Jiang WB (2006). Enhancing disease resistance in harvested mango (*Mangifera indica* L. cv. "Matisu") fruit by salicylic acid. *Sci. Food Agric.* 86:694-698.