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Effects of *Aloe vera* gel coatings and storage temperature on quality of mango (*Mangiferaindica*L.) fruits

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ABSTRACT

Mango (MangiferaindicaL.) 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, 4 concentrations of Aloe vera (AG) (0, 25, 50 and 75%) and chitosan (1%) were tested at two temperature levels (room temperature (15-22^{0}C) and 13^{0}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, Total soluble solids,firmness and pHamong others.The results showed that at 13^{o}C temperature, aloe concentrations significantly increased the shelf life evidenced by reduced percentage weight loss. Fruit firmness and totals soluble solids concentration and pH were also maintained for longer periods in these treatments.. Aloe vera gel as a coating and storage temperature of 13^{o}C for maintaining quality of mango fruits hence reduced postharvest losses.

Key words: *Aloe veragel,temperature, postharvest shelf life, Mango fruit*

INTRODUCTION

Mango (*Mangiferaindica*L.) is the most economically important fruit in the Anacardiaceae family[8]. 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[5]. 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 [12].

The use of *Aloe vera gel* has drawn interest in the food industry[13].*Aloe 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 [10][6][2]. 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 [3]. It has also been reported that *Aloe vera*extracts possess antimicrobial activity against gram positive and gram negative bacterial pathogens[13].

The use of *Aloe 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 [6][7], yet no studies have demonstrated the use of *Aloe 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 *Aloe vera* gel on postharvest life of mango fruits.

Temperature, on the other hand, is an important component that affects quality of mango. Low temperature storage has been used in the enhancement of shelf life and quality maintenance in various fruits. The extension of storage life under cool temperature is due to the reduction in respiration rate and lowering the production of ethylene. However, due to its tropical origin, mango is susceptible to chilling injury at lower temperatures. Storing mango at 13°C has been demonstrated to extend the post-harvest life of mangoes. However, temperature below 10°C causes chilling injury and above 15°C leads to shorter post-harvest storage life [4].

MATERIALS AND METHODS

2.1 Research Site

The postharvest study was carried out in a laboratory at Egerton University, Njoro, Kenya. The laboratory lies at a latitude of 0º 23' South, longitude 35º35' East, altitude of approximately 2,238 meters a.s.l in the Lower Highland 3 (LH3) agroecological zone (Jaetzold and Schmidt, 1983). The laboratory records average maximum and minimum temperatures of 19ºC to 22ºC and 5ºC to 8ºC, respectively (Egerton Metrological Station, 2009).

2.2 Materials

2.2.1 Mango: The variety 'Ngowe' was used. 'Ngowe' 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.

2.2.2 *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.

2.2.3 Chitosan: Crushed chitosan powder food grade was purchased from Kobian Chemicals Company Nairobi.

2.3 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 colourlesshydroparenchyma homogenized in a blender. The resulting mixture was filtered using Watman filter paper number 100 to remove the fibres. The liquid constituted fresh *aloe vera* gel. The gel matrix was pasteurized at 70°C for 45min. For stabilizing, the gel was cooled immediately to an ambient temperature and 4.5g of ascorbic acid was added; 4.5g 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 0.1M NaOH.

2.4 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 13ºC. 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 *Aloe vera* gel at concentrations of 0%, 25%, 50% and 75% respectively and stored at room temperature and at 13ºC (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.

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 ºBrix) (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 fruit firmness using a hand held penetrometer (model 62/DR, UK) with a8 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

Weight Loss
Aloe vera gel concentrations at 50 and 75% at 13°C significantly ($P \leq 0.05$) reduced percentage weight loss (Table 1). At day four, mango fruits coated with 0% *Aloe vera* gel and stored at room temperature (A2T1) had the highest weight losswhile those coated with 75% *Aloe vera* gel and stored at 13°C (A5T2) had the lowest weight loss values. However there was no significant difference between A5T2 and those coated with 50% *Aloe vera* gel and stored at 13°C (A4T2). At day eight, fruits coated with 0% *Aloe vera* gel and stored at room temperature (A2T1) had the highest weight loss while those coated with 75% *Aloe vera* gel and stored at 13°C (A5T2) had the lowest weight loss valueand at day twelve similar observations were made.

At day sixteen, the percentage weight loss was high in all treatments but mango fruits coated with 75% *Aloe vera* gel and stored at 13°C (A5T2) had the lowest weight loss followed by those coated with 75% *Aloe vera* gel at room temperature. Fruits under room temperature were discarded considering the overall acceptability. Generally at 13°C all fruits coated with *Aloe vera* treatments, had the lowest weight loss throughout the entire storage period.

Total Soluble Solids
Aloe gel concentrations at 50% and 75% at 13°C significantly ($P \leq 0.05$) maintained total soluble solids (Table 2). At day zero, there was no significant difference between the treatments, at day four fruits coated with chitosan as a positive control at 13°C (A1T2) had the lowest TSS followed by interactionof *Aloe vera* at 50% at 13°C (A4T2) which had highest value while the lowest TSS value was recorded in the interaction between 0% *Aloe vera* and room temperature. At day eight, mango fruits coated with 0% *Aloe vera* gel and stored at room temperature (A2T1) had the highest TSS while 50% *Aloe vera* gel aloe at 13°C had the lowest TSS value.

At day twelve, the interaction between 75% *Aloe vera* gel and 13°C had the lowest TSS value. Day sixteen, TSS was lowest for A4T2 treatment while 0% *Aloe vera* gel aloe at room temperature had the highest value. Fruits under room temperature were terminated considering the overall visual quality was unacceptable. Generally at 13°C of all aloe treatments had the most reduced increase in TSS and highest TSS was observed in 0% aloe at room temperature.

Fruit Firmness
Aloe vera gel coatings concentrations of 50% and 75% and storage temperature of 13°C significantly ($P \leq 0.05$) reduced loss of fruit firmness (Table 3). At day zero, there was no significant difference between the treatments, at day four *Aloe vera* coated fruits at 13°C were the firmest while the least in firmness was recorded for fruits coated with 0% *Aloe vera* gel and stored at room temperature (A2T1).

At day eight, 0% *Aloe vera* gel coated mango fruits and stored at room temperature (A2T1) had the lowest firmness while those coated with 50% *Aloe vera* gel and stored at 13°C had the highest fruit firmness. At day twelve fruits coated with 75% *Aloe vera* gel and stored at 13°C (A5T2) were the firmest. Day sixteen, firmest fruits were those coated with 75% *Aloe vera* gel and stored at 13°C, 0% *Aloe vera* gel at room temperature had the least firmness. Fruits under room temperature were discarded at day sixteen considering their overall acceptability.

Generally at 13°C all *Aloe vera* gel coated fruits had the most reduced loss of fruit firmness and highest loss in firmness was observed in the interaction between 0% *Aloe vera* gel coatings and room temperature

Fruit Juice pH:

Aloe vera gel concentrations of 50% and 75% interacted with storage temperature of 13°C resulting in a significantly reduced increase in fruit juice pH (Table 4). At day zero, there was no significant difference (P≤0.05) between the fruit coatings; at day four fruits coated with *Aloe vera* at 50%, 75% concentration and chitosan and stored at 13°C had the lowest juice pHwhile the highestpH value was recorded in the interaction between 0% *Aloe vera* coating and room temperature (A2T1). At day eight, the interaction between 0% *Aloe vera* gel and room temperature storage had the highest juice pH while the interaction between chitosan and 13°C resulted in the lowest pH value.

At day twelve, fruits coated with 75% *Aloe vera* gel and at 13°C (A5T2) had the lowest pH value while the highest pH was recorded for A2T1. Day sixteen, pH was lowest for A4T2 and A1T2 treatments while A2T1 had the highestpH value. Fruits under room temperature were discarded considering their overall acceptability. Generally at 13°C all aloe treatments had the most reduced increase in pH while the highest increase was observed in mango fruits coated with 0% *Aloe vera* gel at room temperature.

Table 1: Interactive effects of *Aloe vera* gel concentrations and storage temperature on weight loss

Storage time (Days) Treatment	4	8	12	16
A1T1	4.3abc*	8.9ab	14.3ab	54.3abc
A1T2	2.0de	4.9cd	8.9cd	50.8abcd
A2T1	5.5a	10.6a	16.6a	61.6a
A2T2	4.9ab	9.7a	9.3bcd	59.6ab
A3T1	4.3abc	9.1a	13.5abc	52.0abcd
A3T2	1.9de	5.2cd	8.2cd	46.7bcd
A4T1	3.6bcd	7.7abc	11.3bc	49.8abcd
A4T2	1.6e	4.0d	5.3d	44.9cd
A5T1	2.5cde	5.7bcd	9.8bcd	43.8cd
A5T2	1.3e	3.1d	4.9d	39.9d

**Means followed by the same letter between treatments in a given day are not significantly different according to Tukey's HSD test (P≤0.05) where A1= Chitosan, A2= 0% Aloe vera, A3=25% Aloe vera, A4=50% Aloe vera, A5=75% Aloe vera, T1=Room temperature and T2=13°C*
**Room storage temperature varied between 15 and 22°C.*

Table 2: Interactive effects of *Aloe vera* gel concentrations and storage temperature on total soluble solids.

Storage time (Days) Treatment	0	4	8	12	16
A1T1	12.8a*	12.4bc	16.3abc	17.6ab	19.3abc
A1T2	12.8a	11.6c	15.9abc	17.4ab	18.8abc
A2T1	12.8a	15.6a	18.2a	19.2ab	22.2 a
A2T2	12.8a	14.3ab	17.8ab	19.5 a	20.2ab
A3T1	12.8a	12.8bc	16.5abc	17.9ab	19.5abc
A3T2	12.8a	12.3b	14.5c	15.8ab	16.5 c
A4T1	12.8a	13.5abc	15.4abc	16.8ab	19.5abc
A4T2	12.8a	11.7c	14.2c	15.5b	16.2c
A5T1	12.8a	11.7c	15.4abc	16.0ab	18.5bc
A5T2	12.8a	11.8c	15.0bc	15.4ab	16.5c

**Means followed by the same letter between treatments in a given day are not significantly different according to Tukey's HSD test (P≤0.05) where A1= Chitosan, A2= 0% Aloe vera, A3=25% Aloe vera, A4=50% Aloe vera, A5=75% Aloe vera, T1=Room temperature and T2=13°C*
**Room storage temperature varied between 15 and 22°C.*

Table 3: Interactive effects of *Aloe vera* gel concentrations and storage temperature on fruit firmness

Storage time (Days)					
Treatment	0	4	8	12	16
A1T1	13.0a*	12.7ab	7.5abcd	4.5cde	2.5c
A1T2	13.0a	13.0a	10.0abc	7.0bc	3.7bc
A2T1	13.0a	8.5c	4.3d	3.0e	1.5c
A2T2	13.0a	9.2c	5.3cd	3.3e	2.8bc
A3T1	13.0a	10.7bc	6.3bcd	4.0de	2.7c
A3T2	13.0a	13.0a	11.0ab	5.8cde	4.3bc
A4T1	13.0a	13.0a	10.5abc	6.7bcd	4.3bc
A4T2	13.0a	13.0a	12.0a	9.3ab	6.2ab
A5T1	13.0a	13.0a	11.0ab	9.0ab	4.5bc
A5T2	13.0a	13.0a	12.5a	11.0a	8.7a

**Means followed by the same letter between treatments in a given day are not significantly different according to Tukey's HSD test (P≤0.05) where A1= Chitosan, A2= 0% Aloe vera, A3=25% Aloe vera, A4=50% Aloe vera, A5=75% Aloe vera, T1=Room temperature and T2=13°C *Room storage temperature varied between 15 and 22°C.*

Table 4: Interactive effects of aloe gel concentrations and storage temperature on fruit juice pH.

Storage time (Days)					
Treatment	0	4	8	12	16
A1T1	3.3a*	3.5e	3.9cd	5.2c	5.3d
A1T2	3.3a	3.4e	3.4f	4.3de	4.5h
A2T1	3.3a	5.2a	5.6a	6.0a	6.2a
A2T2	3.3a	4.7b	5.1b	5.6b	6.0b
A3T1	3.3a	3.7c	4.1c	5.3c	5.8c
A3T2	3.3a	3.6d	3.9cd	4.4de	4.7f
A4T1	3.3a	3.4e	3.7de	4.4de	5.2e
A4T2	3.3a	3.4e	3.6def	4.3de	4.5h
A5T1	3.3a	3.5e	3.8d	4.4d	5.3de
A5T2	3.3a	3.4e	3.5ef	4.2e	4.6g

**Means followed by the same letter between treatments in a given day are not significantly different according to Tukey's HSD test (P≤0.05) where A1= Chitosan, A2= 0% Aloe vera, A3=25% Aloe vera, A4=50% Aloe vera, A5=75% Aloe vera, T1=Room temperature and T2=13°C *Room storage temperature varied between 15 and 22°C.*

DISCUSSION

The highest weight loss suppression was achieved with the interaction of the 75% *Aloe vera* gel coating and storage temperature of 13°C. *Aloe vera* gel coatings and chitosan coating and low storage temperature greatly reduced weight loss in mango fruits. *Aloe vera* gel-coating significantly reduced weight loss during fruit ripening and during low temperature storage compared to uncoated fruit. Fruit weight loss occurs as a result of dehydration and loss of water from fruit surface. Earlier reports on mango showed higher weight loss with increased fruit ripening and storage periods [1]. *Aloe vera* gel coating reduced weight loss in coated fruit because of hygroscopic properties that enable the formation of a barrier to water diffusion between fruit and environment [6]. Similar reductions in weight loss have been reported in *Aloe vera* coated sweet cherry and table grapes [10] [6].

The lower total soluble solids in *Aloe vera* gel coated and chitosan coated fruits stored at low temperature might be due to delayed fruit ripening. Similarly a delayed and a smaller increase in TSS has been reported in *Aloe vera* gel coated sweet cherry and table grapes [10] [6], and in starch-coated strawberry fruit [11].

Aloe vera gel and chitosan coatings and low temperature resulted in a significant retention of fruit firmness during ripening compared to the uncoated fruit. This was possibly due to reduced ethylene production consequently delaying the fruit ripening process in mango fruits with *Aloe vera* gel coating[13]. Generally, fruit softening involves structural as well as compositional changes in the various components of the cell wall carbohydrates partly as a result of action of fruit softening enzymes [1]. Fruit softening has been reported to be a result of cell wall digestion by pectinesterase, polygalacturonase and other enzymes, and this process is increased by the increase in storage temperature [2]. Similar results have been reported in *Aloe vera* gel coated sweet cherry and table grapes [10] [6].

It was found that *Aloe vera* gel and chitosan coated mangoes under low temperature had lower value of pH at the end of storage period; this was due to the semi-permeability created by *Aloe vera*coatings on the surface of the fruit,

which might have modified the internal atmosphere i.e. endogenous O2 and CO2 concentrations in the fruit, thus retarding ripening[13].

CONCLUSION

Findings of this study demonstrate the potential of using*Aloe vera*g1el coatings at storage temperature of 13^{o}C. *Aloe vera* gel as a coating and storage temperature of 13^{o}C formaintaining quality of mango fruits hence reduced postharvest losses. The results showed that at 13^{o}C temperature, 50 and 75% aloe concentrations significantly maintained quality evidenced by reduced increase in weight loss. Total soluble solids and Firmness and pH were also maintained for twenty days in these treatments.Since *Aloe vera* is an edible plant, does not pose any environmental hazard and is easily available in Kenya and other tropical regions, *Aloe vera* at storage temperature of 13^{o}Ccan be used for mangoes storage.

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