

Preparation and Utilization of Natural Aloe Vera to Enhance Quality of Mango Fruit

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Abstract: The main objective of this study was to see the effect of natural Aloe vera gel coating, and combined with citric acid treatments on shelf life and quality of mango during storage. Mango fruit is very perishable in nature and considerable postharvest quality defect is occurred during and after harvest. Postharvest loss on fruits especially mango fruit is common in Ethiopia especially areas like *North Shewa Administrative Zone, Shewa Robit, Ethiopia* due to hot and humid condition (16.5-31°C) and poor fruit harvesting transporting, handling and storage condition by farmers, wholesalers and consumers. Physico-chemical parameters such as weight loss, pH, moisture, titratable acidity and total soluble solids (TSS) of mango fruit was determined at 7 days interval during the storage period. The control fruits started deteriorated before 17 days and only few fruits survived up to 21 days, whereas, shelf life extended to 29 days for majority of aloe vera gel alone and with citric acid coated fruits. At the end of the storage period, uncoated mango fruits showed 22.04% loss in weight, whereas coated mango fruits with aloe vera gel and combination with citric acid was 8.6% and 7.6% by weight loss, respectively. Among the physico-chemical parameters, pH and TSS contents increased significantly ($p \leq 0.05$), whereas total weight loss, moisture content and titratable acidity decreased during storage. The present work reveals that potential application of natural aloe vera (*Aloe debrana*) gel with citric acid coatings for enhancing the postharvest shelf life and maintaining quality of mango fruit.

Keywords: Mango, Physico-chemical, Postharvest, Shelf Life, Storage

1. Introduction

Consumers around the world demand for food of high quality, without chemical preservatives, and an extended shelf life. Therefore, an increased effort has been made to develop new natural preservatives and antimicrobials [3]. Many storage techniques have been developed to extend the marketing distances and holding periods for commodities after harvest. Different preservation methodologies have been developed.

One method of extending postharvest shelf life is the use of the edible coatings. The coating technology is one of the important and popular techniques used to prolong the shelf life and reduce their wastage. Edible films and coatings have received considerable attention in recent years because of their advantages including use as edible packaging materials over synthetic films. Edible coatings create a modified atmosphere around the fruit by providing a semi permeable barrier to water vapor and gases, and their use offers an attractive alternative to

film packaging due to their environmentally friendly characteristic [8]. They are applied directly on the food surface by dipping, spraying or brushing [5].

Aloe vera gel is a novel edible coating for organic fruit storage technology. Aloe vera gel-based edible coatings have been shown to prevent loss of moisture and firmness, control respiratory rate and maturation development, delay oxidative browning and reduce microorganism proliferation in fruits such as table grapes [2] sweet cherries [4] and table grapes [10].

Citric acid (CA) is an anti-browning agent, which prevents polyphenol oxidase (PPO) by suppressing the food pH and binding the Cu^{2+} in an active site of PPO to form an inactive component. It has also been widely used in the food industries for controlling the browning. Applying CA as a dipping solution has been reported in postharvest fruits with very satisfactory results for fruits such as longan [9].

Mango fruit is very perishable in nature and considerable postharvest quality defect is occurred during and after

harvest. Hence, mango fruit is susceptible to postharvest damage, pest and disease attack and considerable yield loss occurs during harvesting, transporting, handling and storage condition. Postharvest major defects on mango fruit may be common in Ethiopia especially at areas like Shewa Robit due to hot and humid condition and poor fruit harvesting and handling by farmers and retail wholesalers. Therefore, this study was aim at the shelf life extension of mango using natural aloe vera gel and citric acid treatment.

2. Materials and Methods

2.1. Raw Material Collection, Transportation and Preparation

The research materials for this study were Aloe vera leaves

(*Aloe debrana*), citric acid and Mango fruit (*keitt*). The fresh leaves of Aloe vera leave was collected and transported from around *cha cha* place from Debre berhan 17 km.

Mango (*keitt*) was collected from Shewa Robit integrated research and development site of Debre Berhan University. The site is found North Shewa administrative zone, Shewa Robit, Ethiopia. Shewa Robit is located at about 225 km North East of Addis Ababa (Figure 1). It is located at 11° 55' N latitude and 37° 20' E longitude with an elevation of 1280 meters above sea leve. The area has an average annual rainfall of 1007 mm, with short rain between March and April and long rain between June and September, and annual mean minimum and maximum temperatures of 16.5 and 31°C, respectively.



Figure 1. Location of source of Mango Fruit (World Google Maps, June 2014).

The fruit was harvested by hand at hard green stage of maturity (Figure 2). Sample preparation and all treatment measurements were done in Debre berhan University, College of Technology, Chemical Engineering department laboratory.

Preparation of Aloe vera coating solution

Freshly harvested aloe vera leaves was first washed with tap water and then distilled water. The extraction was performed according to the method described by [7]. The lower leaf base, the tapering point of the leaves top and the short, sharp spines located along the leaves margins was first removed by a sharp knife.



Figure 2. Collected Mango Fruits.

Then the knife was introduced into the mucilage layer below the green rind avoiding the vascular bundles and the top rind is removed (Figure 3).



Figure 3. Colorless hydro parenchyma.

The colorless hydro parenchyma obtained was homogenized in to solution using blender at room temperature and the solution was filtered using cheesecloth. The clear aloe extract is susceptible to enzymatic degradation. The extract was stored at 4°C until used for further analysis.

2.2. Experimental Treatments and Design

The experiment comprised of three treatments viz., control (T_0), aloe vera gel solution (T_1), aloe vera gel with citric acid solution (T_2). Sources of variation were time of storage and treatments, and the interaction of treatments \times storage time with three replications where physicochemical properties were analyzed at seven days intervals during the storage period.

2.3. Application of Experimental Treatments

The fruit was harvested by hand at green stage of maturity,

randomly. The fruit was cleaned carefully by washing it with water to remove all foreign matters, such as dust and dirt. Maximum efforts were used to select the fruit uniform in size, good in quality and free from injury or disease. The materials used for coating were Aloe vera gel (T_1), Aloe vera gel with citric acid (T_2) and fruit without coating (control, T_0) was used.

Cleaned mango fruits were treated with aloe vera gel, aloe vera gel combined with citric acid solution (1%). Treatments were performed by immersion for 5 min with a solution of aloe vera gel (Figure 4).



a) coating of mango fruit.



b) coated mango fruit.

Figure 4. Immersion of mango fruits with a solution of aloe vera gel.

Following treatment, all mango fruits were air-dried for 60 min before storage at room temperature for 35 days. There is 3 replications for each treatment both treated and control fruits will be taken after 0, 7, 14, 21, 28, and 35 days; for quality evaluation like weight loss, P^H of fruit juice, total soluble solids, titratable acidity, soluble solid contents.

2.4. Statistical Analysis

The collected data on various parameters obtained from the experiment was subjected to appropriate statistical tools

of JMP version 5 (SAS Institute Inc., Cary, NC, USA). Sources of variation were time of storage and treatments, and the interaction of treatments \times storage time. Comparisons between sample treatments were done using analysis of variance (ANOVA). Student's *t*-test was used to identify significant differences by comparing means for processing method. Accordingly, ANOVA, mean comparison and significance were set at 5% level.

3. Result and Discussion

3.1. Effect of Coating on Fruit Weight Loss

Table 1 shows the weight loss of mature mango fruits surface-coated with aloe vera gel and stored for different periods of time (0–35 days) at room temperature. All samples demonstrated a gradual loss of weight during storage. Weight loss mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration. The rate at which water is lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere. Aloe gel based edible coating act as barrier, thereby restricting water transfer and protecting fruit skin from mechanical injuries.

Throughout storage, the weight loss of uncoated fruit (sample) was significantly greater than that of Aloe gel

coated fruit. At the end of the storage, uncoated mango showed 22.04% loss in weight, whereas the weight losses of samples coated with Aloe vera gel was 8.6% and with aloe vera with citric acid coated fruit samples shows a 7.6% weight loss. This positive effect in terms of reduction of moisture loss may be due to the hygroscopic properties of Aloe gel that allow the formation of water barrier between the fruit and the surrounding environment. Thus, preventing its external transferences [6]. Additionally, Aloe vera gel mostly composed of polysaccharide which is highly effective as a barrier against moisture loss without incorporation of lipid. Similar reductions in weight loss have been reported in Aloe vera coated sweet cherry and table grapes [4].

3.2. Effect of Coating on Moisture Loss

The results indicate that the moisture content was gradually decreased during the storage period. The moisture content was higher in control mango compared to aloe vera gel, aloe vera with citric acid treatment (Table 1). The decrease in moisture content during storage was also reported by [11]. The decrease of moisture content was probably due to transpiration and evaporation loss and also due to starch hydrolysis.

Table 1. Effects of aloe vera coating on weight loss and moisture content of mango fruits.

Storage time	Weight loss (%)			Moisture Loss (%)		
	T ₀	T ₁	T ₂	T ₀	T ₁	T ₂
0DAS	231.5 \pm 0.7 ^a	349.41 \pm 0.4 ^b	258.1 \pm 0.3 ^c	68.13 \pm 0.2 ^a	69.4 \pm 0.1 ^b	68.47 \pm 0.2 ^a
7DAS	210.1 \pm 0.11 ^a	322.4 \pm 0.1 ^b	251.5 \pm 0.2 ^c	58.47 \pm 1.36 ^a	65.4 \pm 0.1 ^b	65.8 \pm 0.6 ^b
14DAS	190.17 \pm 0.2 ^a	336.92 \pm 0.6 ^b	246.4 \pm 0.4 ^c	47.67 \pm 0.15 ^a	60.87 \pm 0.06 ^b	61.9 \pm 0.36 ^c
21DAS	180.47 \pm 0.6 ^a	319.46 \pm 1.8 ^b	241.43 \pm 0.5 ^c	42.8 \pm 0.1 ^a	59.1 \pm 0.7 ^b	59.3 \pm 0.7 ^b
28DAS	-	280.1 \pm 0.1 ^a	238.4 \pm 0.0 ^b	-	56.4 \pm 0.2 ^a	55.1 \pm 0.2 ^b

Where T₀ –control, T₁–alovera gel, T₂–alovera with citric acid, DAS- Days after storage, Values in the same row (control and coated) not connected with same letter are significantly different. Values are mean and SD of three separate determinations.

3.3. Effect of Coating on PH Values

There is an increment of the P^H values throughout the storage time (Table 2). P^H value of control at the time of storage on the 21th day was 5.21, whereas for aloe vera gel coated fruit it was 4.31 and aloe vera with citric acid storage

3.89. The increase in pH value may be due to break-up of acids with respiration during storage. The pH value of aloe vera gel coated fruit and aloe vera with citric acid coated fruit was increased to 5.21 and 4.96, respectively, during storage on the 28th day.

Table 2. Effects of aloe vera coating on pH of mango fruits.

Storage Time	pH value		
	T ₀	T ₁	T ₂
0DAS	3.14 \pm 0.02 ^a	3.26 \pm 0.01 ^b	3.62 \pm 0.0 ^c
7DAS	3.28 \pm 0.0 ^a	3.88 \pm 0.01 ^b	3.77 \pm 0.01 ^c
14DAS	4.47 \pm 0.06 ^a	3.98 \pm 0.0 ^b	3.79 \pm 0.01 ^c
21DAS	5.21 \pm 0.01 ^a	4.31 \pm 0.01 ^b	3.89 \pm 0.08 ^c
28DAS	-	5.21 \pm 0.01 ^a	4.96 \pm 0.0 ^b

Where T₀ –control, T₁–alovera gel, T₂–alovera with citric acid, DAS- Days after storage, Values in the same row (control and coated) not connected with same letter are significantly different. Values are mean and SD of three separate determinations.

3.4. Effect of Coating on Total Soluble Solid

Aloe vera gel treated fruits showed a lower increase (Table 3) in TSS (Total Soluble Solid), which indicated that control fruits presented a more pronounced maturation development

than coated berries during storage periods. The increase in TSS of control mango was mainly due to the progressive boost in free sugars of mango during storage periods.

In case of Aloe vera with citric acid coated fruits, decrease TSS content of fruits during storage periods. This is due to

the value of ascorbic acid content for coated mango fruits were found to be higher than that of uncoated fruits. Similarly, [1], found that ascorbic acid content was higher in Aloe coated papaya fruits than the control fruits during the storage period at temperatures 25°C-29°C and 82-84% RH.

Citric acid coated mango retarded TSS development because aloe gel decreases the respiration and eventually metabolism of sugars. This may be due to the effect of aloe vera gel coating on the reduction of α -galactosidase, polygalacturonase and pectinmethylesterase activities.

Table 3. Effects of aloe vera coating on TSS mango fruits.

Treatment	TSS (%)				
	0DAS	7DAS	14DAS	21DAS	28DAS
To	18.18±0.06 ^a	19.48±0.54 ^a	24.0±0.18 ^a	26.6±0.42 ^a	-
T1	18.31±0.09 ^a	19.33±0.076 ^a	22.34±0.19 ^B	23.8±0.0 ^a	23.6±0.18 ^a
T2	17.91±0.5 ^a	19.17±0.06 ^a	21.75±0.07 ^C	22.62±0.28 ^a	22.12±0.18 ^b

Where T₀ –control, T₁-aloe vera gel, T₂-aloe vera with citric acid, DAS- Days after storage, Values in the same column (control and coated) not connected with same letter are significantly different. Values are mean and SD of three separate determinations.

The results revealed that surface coating produced an effective semipermeable film around the fruit and modified the internal atmosphere of fruit by reducing O₂ and/or elevating CO₂ and reducing the production of ethylene. Decrease in TSS of coated fruit had a direct relation to the aloe vera solution used for coating. Lower rates of respiration also reduce the synthesis and utilization of metabolites that result in lower TSS [13]. Furthermore, the reduction of TSS during storage is generally due to sugar–acid metabolism.

3.5. Effect of Coating on Titratable Acidity

The values for TA of coated and uncoated fruit during storage were found to decrease with storage time (Table 4),

and the rate of decline was significantly higher for the control fruits than for coated ones. The low level of TA in the control fruits compared with surface coated fruits shows that aloe vera coating prevented further ripening by creating a semi permeable film around the fruit. This retention of TA content by coated mango was due to the protective effect of aloe gel coating as a barrier to O₂ from the surrounding atmosphere and reduction of respiration [12].

It has been also reported that the TA values of coated and uncoated mature green fruit of tomato during storage decreased with storage time, and the values were coating can reduce the respiration rate and may therefore prevent or delay the consumption of organic acids in respiration [13].

Table 4. Effects of aloe vera coating on TA mango fruits.

Treatment	TA (%)				
	0DAS	7DAS	14DAS	21DAS	28DAS
To	0.606±0.02 ^a	0.607±0.01 ^a	0.53±0.01 ^a	0.42±0.01 ^a	-
T1	0.573±0.0 ^b	0.573±0.0 ^b	0.527±0.0 ^a	0.46±0.0 ^b	0.42±0.0b
T2	0.59±0.0 ^b	0.587±0.02 ^b	0.54±0.01 ^a	0.47±0.01 ^C	0.43±0.0 ^b

Where T₀ –control, T₁-aloe vera gel, T₂-aloe vera with citric acid, DAS- Days after storage, Values in the same column (control and coated) not connected with same letter are significantly different. Values are mean and SD of three separate determinations.

3.6. Effect of Coating on Shelf life of Mango Fruits

In general, the results showed that the application of aloe vera coating with citric acid solution shows a longer storage time than control fruits. Aloe vera gel had an impact to extend the postharvest quality parameters during storage time. The control fruits started deteriorated before 17 days and only few fruits survived up to 21 days, whereas, shelf life extended to 29 days for majority of aloe vera gel alone and with citric acid. This could be attributed to the delayed ripening process. In climacteric fruits like mango, an increase in ethylene production during ripening is a normal physiological process. Reduction of ethylene production was higher in aloe vera gel with citric acid coated mango than aloe vera gel coated mango and control mango fruits.

additional shelf-life benefits to the fruit. Comparing with the uncoated mango fruits, all the coated fruits showed significantly reduced weight loss and delayed changes in the ripening parameters such as TSS, TA and % moisture loss levels ($p \leq 0.05$). In addition, the aloe vera treatments combined with citric acid (1%) led to rachises with better freshness without browning symptoms after 21 days of storage.

This work assures that aloe vera gel coating as a successful bio-preservative and a useful alternative to synthetic preservative. To effectively extend the shelf life of postharvest fruits, aloe vera gel based coating as a relatively convenient and safe measure. Aloe vera based coating is totally harmless to the environment. In fact it can be considered as a green alternative to synthetic coatings and other postharvest chemical treatments.

Dipping into an Aloe vera extract and combining with citric acid allowed to reduce the respiration rate of mango fruit and was effective at reducing the enzymatic activities commonly considered as responsible for the quality decay.

4. Conclusion

The application of coatings using this naturally available organic resources like aloe vera could easily be integrated in the current handling system of fruit and would provide

Also, the general aspect and browning extent confirmed the ability of mango coating with aloe vera combined with citric acid to maintain better quality for at least 21 days compared to untreated mango fruits.

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