International Journal of Food Studies | IJFS April 2013 | Volume 2 | pages 126–136

Effect of Biopreservatives on storage life of papaya (*Carica papaya* L.)

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Received: 31 August 2012; Published online: 18 April 2013

Abstract

In this experiment the effect on post-harvest preservation of papaya (*Carica papaya* L.) fruit coated with either Aloe gel (AG; 100%) or papaya leaf extract with Aloe gel (PLEAG; 1:1) was studied. To evaluate the role of coating on ripening behavior and quality of papaya the uncoated and coated fruits were stored and ripened at room temperature (25 ºC-29 ºC) and 82-84% relative humidity. Physico-chemical properties were analyzed at 4 day intervals during the storage period. The incidence of disease attack was also visually observed. The overall results showed the superiority of AG and PLEAG coating in lengthening the shelf-life of papaya fruit compared to controls which showed significant decay from 6^{th} day onward and complete decay within 12 days of storage. The AG and PLEAG coated fruits maintained their shelf life for 12 days and decayed at 16^{th} day. The coated fruits also maintained their color, flavor and firmness up to 12 days of storage. An increase in ascorbic acid content (120.2 mg/100 g) was also found in coated fruits in contrast to the control (59 mg/100 g). Only 27% disease incidence was observed in AG and 13% in PLEAG coated fruits as compared to control (100%) during the storage period. The results of this study show that both AG and PLEAG coatings have excellent potential to be used on fresh produce to maintain quality and extend shelf-life.

Keywords: *Aloe vera* gel; papaya fruit; post-harvest; disease incidence; edible coating

1 Introduction

Papaya (*Carica papaya* L.) is a popular and economically important fruit of tropical and subtropical countries. Papaya ranks first among 13 to 17 fresh fruits for vitamin C content per 100 grams edible tissue (Gebhardt & Thomas, 2002). As a human food, they are of excellent flavor and sweetness, and their nutritional value is high. One serving of papaya will meet about 20% of an adult's daily folate needs, and provides about 75% of an adult's daily vitamin C needs. Papaya fruits are rich in enzymes called papain and chymopapain used for meat tenderizing and chewing gum (Oloyede, 2005). Marketing of fresh papaya is a great problem because of its short post-harvest life, which leads to high post-harvest losses (Jayathunge, Prasad, Fernando, & Palipane, 2011). Papaya fruits soften rapidly at room temperature after harvest and a 2 to 3 day shelf life is to be expected (Archbold, Koslanund, & Pomper, 2003). If the fruits are not quite ripe, they may be refrigerated for about two weeks. There are few studies on the efficacy of edible coatings to reduce the perishability of papayas. Films and edible coatings are defined as "a thin application of material that forms a protective barrier around

 10.7455/ijfs/2.1.2013.a10

an edible commodity and can be consumed along with the coated product" (Guilbert, Gontard, & Gorris, 1996). Edible coatings are used to create a modified atmosphere and to reduce weight loss during transport and storage (Baldwin, 1994). In fact, the barrier characteristics to gas exchange for films and coatings are the subjects of much recent interest (Tripathi & Dubey, 2004).

Aloe vera is a well-known plant for its marvelous medicinal properties. It is a tropical and subtropical plant. There are some reports on the antifungal activity of *Aloe vera* gel against several fungi including *Colletotrichum* sp. (Nidiry, Ganeshan, & Lokesha, 2011). Recently, interest has increased in using *Aloe vera* gel-based edible coating material for fruits and vegetables driven by its antifungal activity. Researchers from Spain have developed a gel based on *Aloe vera* that prolongs the conservation of fresh fruits (Valverde et al., 2005). This gel is tasteless, colorless and odorless. This natural product is a safe and environmentally friendly alternative to synthetic preservatives such as sulfur dioxide. According to the researchers, this gel operates through a combination of mechanics (Serrano et al., 2006), forming a protective layer against the oxygen and moisture of the air and inhibiting the action of micro-organisms that cause food borne illnesses through its various antibacterial and antifungal compounds. *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 (Castillo et al., 2010), sweet cherries (Martinez-Romero et al., 2006) and nectarines (Ahmed, Singh, & Khan, 2009).

Furthermore, papaya leaf contains bioactive compounds which have antifungal (Bautista-Baños, Barrera-Necha, Bravo-Luna, & Bermúdez-Torres, 2002) activity against *Colletotrichum* sp. Thus, the extracts of papaya leaf can be incorporated into Aloe vera gel to enhance the effectiveness of the anti-fungal activity of Aloe gel matrix.

In view of *Aloe vera's* favorable effect on fruits (sweet cherries, table grapes, granny smith and red chief apple) and increasing demands for eco-friendly, bio-based preservatives for post-harvest conservation of fresh produce, this investigation was conducted. The goal of this work was to analyze the efficacy of Aloe gel and papaya leaf extract incorporated Aloe gel-based coatings on storage life, disease incidence and quality attributes of papaya such as weight loss, total soluble solids (TSS), titrable acidity, pH, ascorbic acid content, firmness and color changes.

2 Materials and Methods

2.1 Plant materials

Papayas (*Carica papaya* L.) were harvested at the preclimacteric stage ("nearly ripe"), with green color, though physiological maturation (local variety), from the Bibidoil village at lalabazar in Sylhet (24º 55' 00" N, 91º 46' 00" E), Bangladesh. Visually blemished, diseased, damaged papayas were discarded to minimize biological variability.

Biopreservatives

Aloe vera leaves were collected from Natore district (24.4139ºN, 88.9300ºE), Bangladesh. Papaya leaves were obtained from a papaya orchad in Shubid bazaar and Tilagor of Sylhet division, Bangladesh.

2.2 Methods

Fresh *Aloe vera* leaves were taken. Aloe gel matrix lies underneath the green outer leaf rind. The gel matrix was separated from the outer cortex of leaves and this colorless hydroparenchyma was ground in a blender. The resulting mixture was then filtered to remove the fibers. The liquid obtained was the fresh Aloe gel (AG; 100%). The Aloe gel was pasteurized at 70 ºC for 45 min (Maughan, 1984). It was then cooled immediately at ambient temperature. To facilitate coating the gel was thickened using 1% gelling agent (High Methoxyl pectin, Anhui Yuning Bio-Technology Co., Ltd, Wanguo).

To prepare papaya leaf extract along with Aloe gel (PLEAG, 1:1), 500 g papaya leaves were first washed with running water. After that the leaf surface was sterilized using 0.1% mercuric chloride for 10 min (El-Kadder & Hammad, 2012) and again washed thoroughly with sterile distilled water. Papaya leaves were then crushed along with Aloe gel. Filtration was carried out to remove fiber.

2.3 Treatments

For each treatment 25 fruits were used. Fruits were first washed and dried at room temperature. Then 100% AG and PLEAG (1:1) were brushed on papaya fruits and allowed to dry for about 1 hr at room temperature. All the fruits were air-dried to form a thin film on the fruit surface and stored in bamboo baskets. Uncoated fruits were used as control and stored under the same storage conditions used for AG and PLEAG coated fruits. Physico-chemical properties were measured initially and at 4-day intervals. The experiments were replicated five times.

2.4 Total Soluble Solids (TSS) and pH

TSS of papaya juice was determined using a Hand Held Refractometer (REF102/112, China) and the data were recorded as $^{\text{o}}$Brix. pH was measured using a digital pH meter (Jenco 6173/R, China) and the data recorded.

2.5 Size

Fruit size was measured using vernier caliper with an accuracy of 0.05 mm and then average values calculated.

2.6 Titrable acidity (TA) and ascorbic acid

Whole fruits were passed through an electric juicer (Nova Osaka Japan, NJ-506) and filtered. TA was determined by titration of 2 ml juice diluted with 25 ml distilled water with 0.1N NaOH using 1% phenolphthalein as indicator and expressed as percentage citric acid (Mitcham, Cantwell, & Kader, 2003).

Ascorbic acid was determined by iodine titration (AOAC, 2000).

2.7 Weight loss

Fruits for each treatment were marked before storage and weighed using a digital electronic balance with an accuracy of 0.0001 g. Calculation was done from the weight of each papaya measured initially and at 4-day intervals during storage (Equation 1).

$$\%\text{Weight loss} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \quad (1)$$

2.8 Percentage Disease Index (PDI)

Disease index was measured by assessing the number of fruits infected during storage period. It was performed to check the ability of the coating material to prevent fruit disease. It was calculated as % disease index (Equation 2):

$$\begin{aligned} \text{PDI} = \text{no. of infection categories/no.} \\ \text{of infected fruit falling to this category} \times \\ 100/\text{maximum no. of infection categories.} \end{aligned} \quad (2)$$

Infection categories were: 0 = no lesion; 1 = 5 to ≤ 15 %; 2 = $\geq 15\%$ to ≤ 25 %; 3 = $\geq 25\%$ to $\leq 50\%$; 4 = ≥ 50 % to $\leq 75\%$; 5 = $\geq 75\%$. For estimation of fruit area diseased, the whole fruit area was considered as 100% and thus the infected area was determined by visual estimation for percent of disease Index (Hossain, Hossain, Bakr, Rahman, & Uddin, 2010).

2.9 Peel color, flavor and firmness

Fruits were evaluated for their firmness, color, flavor and overall acceptability. This was carried out by a panel of 10 members to make judgment more accurate. Peel color was measured visually based on skin color change initially and during storage intervals. Color was assessed visually by matching sample fruits with 'Maturity stages of Maradol papaya' (Basulto et al., 2009) with some modification. For each treatment 25 fruits

were used. Five fruits were assessed at each interval. For control treatment initially (0 day) all the fruits were bright green, so this was expressed as 100% bright green. At 4-day intervals fruits were assessed for ratios of green to yellow coloration, and color percentages were calculated.
Subjective (non-destructive) fruit firmness was recorded by finger pressure using the scale: 6 = very firm; 5= firm; 4 = moderately firm; 3= slightly soft; 2 = soft; 1= very soft. In order to obtain more accurate data, a panel of 10 members was employed instead of one person as tester (Shahnawaz & Sheikh, 2011). The overall flavor of all papaya was perceived by the nose by the panel members to detect whether the flavor was satisfactory enough for consumer acceptance.

2.10 Statistical analysis

Physico-chemical results were subjected to analysis of variance (one way ANOVA) using SPSS package (version 17). Treatment means were separated by comparing the means at $p \leq 0.05$ using Duncan's Multiple Range Test (Duncan, 1951).

3 Results and discussion

3.1 pH value

The pH increased significantly ($P \leq 0.05$) with increased storage time both in uncoated and coated fruits (Table 1). The mean pH value of the control fruits was 8.76 whereas minimal change was noticed in pH values of AG (7.80) and PLEAG (7.60) coated fruits after 8 days storage. After 12 days storage the pH values of the coated fruits increased further with the lowest value (7.98) in PLEAG coated fruits. Coatings slowed the changes in pH, effectively delaying fruit senescence. This was due to the semi-permeable coating on the fruit surface which modified the internal atmosphere i.e., the endogenous CO_2 and O_2 concentration of the fruit. This statement is supported by the study of Bai, Huang, and Jiang (1988). The organic acids present in papaya are largely citric acid and malic acids. The increase in pH during storage was due to the metabolic processes of the fruit that resulted in a decrease of the organic acids Coseteng and Lee (1987).

3.2 Total soluble solid content

The coating with two bio-preservatives (PLEAG) led to a smaller increase in TSS content than the control fruits (Table 1). Data showed that control fruits had significantly ($p \leq 0.05$) higher levels of TSS(10.67) after 8 days storage, whereas the lowest value (7.40) of TSS was found in the PLEAG coated fruits after 12 days storage. The increase in TSS of control fruits was mainly due to the progressive boost in free sugars of fruit during storage periods, as reported by Cheour et al. (1990). Coated fruits retarded TSS development because aloe gel decreases the respiration and eventually catabolism of sugars. A similar result was found in Aloe gel-coated nectarines (Ahmed et al., 2009).

3.3 Titrable acidity (TA)

TA is an important parameter that determines the quality of papaya fruit and can affect consumer acceptance. Very high or very low acidity content is not recommended for good fruits. Control fruits showed rapid decrease in TA whereas coated fruits retained their TA content (Table 2). Control fruits had the lowest value (0.052) of TA ($p \leq 0.05$) after 8 days storage while highest TA retention was found in PLEAG coated fruits (0.142) after 12 days storage. This retention of TA content by coated fruits was due to the protective effect of aloe gel coating as a barrier to O_2 from the surrounding atmosphere (Valverde et al., 2005). This result was also found in semperfresh coated pepper (Ozden & Bayindirli, 2002), starch in strawberries (Mali & Grossmann, 2003), in mango pulp (Baldwin et al., 1999), chitosan in lychee (Jiang, Li, & Jiang, 2005), *Aloe vera* gel in table grape (Castillo et al., 2010) and aloe gel in 'star king' cherries (Martinez-Romero et al., 2006).

3.4 Weight loss percentage (WLP)

Papaya contains about 90% water by weight (Jayathunge et al., 2011). Weight loss mainly occurs due to water loss by transpiration and loss of carbon reserves due to respiration (Zagory & Kader, 1988). The rate at which water is

Table 1: Effect of coatings on pH and total soluble solids (TSS) of papaya

	pH			TSS		
Period	**Control**	**AG**	**PLEAG**	**Control**	**AG**	**PLEAG**
0 d	7.7 ± 0.27^a	7.56 ± 0.37^a	7.40 ± 0.41^a	6.80 ± 0.44^a	6.6 ± 0.54^a	6.80 ± 0.44^a
4 d	8.24 ± 0.25^a	7.58 ± 0.42^a	7.44 ± 0.55^a	9.2 ± 0.83^b	6.80 ± 0.44^a	5.80 ± 1.7^a
8 d	8.76 ± 0.23^b	7.80 ± 0.46^a	7.60 ± 0.49^a	10.67 ± 1.15^b	7.00 ± 1.15^a	6.20 ± 0.83^a
12 d	**	8.36 ± 0.05^a	7.98 ± 0.39^a	**	8.7 ± 1.15^a	7.40 ± 0.54^a

** Indicates complete damage of fruits
# Significance tests were carried out during storage period. Mean ± S.D. in a row followed by different letters are significantly (p≤ 0.05) different (DMRT).
(AG: Aloe gel-coated fruits; PLEAG: Papaya leaf extract incorporated Aloe gel-coated fruits).

Table 2: Effect of coatings on acidity content and weight loss of papaya

	Titrable acidity			Weight loss		
Period	**Control**	**AG**	**PLEAG**	**Control**	**AG**	**PLEAG**
0 d	0.19 ± 0.01^a	0.194 ± 0.00^a	0.194 ± 0.00^a	0.00^a	0.00^a	0.00^a
4 d	0.150 ± 0.01^a	0.174 ± 0.02^{ab}	0.188 ± 0.02^b	17.22 ± 1.45^b	15.18 ± 1.77^b	12.00 ± 2.09^a
8 d	0.052 ± 0.00^a	0.130 ± 0. 05^b	0.158 ± 0.03^b	22.5 ± 0.70^a	7.93 ± 2.76^b	6.5 ± 0.79^b
12 d	**	0.116 ± 0.00^a	0.142 ± 0.02^a	**	10.70 ± 0.50^a	8.71 ± 0.53^b

** Indicates complete damage of fruits
# Significance tests were carried out during storage period. Mean ± S.D. in a row followed by different letters are significantly (p≤ 0.05) different (DMRT).
(AG: Aloe gel coated fruits; PLEAG: Papaya leaf extract incorporated Aloe gel coated fruits)

lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere. Generally, the WLP increased gradually (p≤ 0.05) during storage (Table 2). Control fruits had significantly (p≤ 0.05) higher WLP (22.5%) whereas lower WLP (6.5%) was found in PLEAG coated fruits after 8 days storage.
Table 2 shows that for coated fruits WLP decreased on the 8^{th} day compared to the 4^{th} day. A similar result was also found in apricot fruit treated with 0.75% chitosan (Ghasemnezhad, Shiri, & M. 2010). This was 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 (Morillon, Debeaufort, Blond, Capelle, & Voilley, 2002). Similarly aloe gel also suppressed weight loss for 'Arctic Snow' nectarines treated with 2.50% aloe gel stored at 20 ºC (Ahmed et al., 2009), 'star king' cherries treated with 33% aloe gel at 1 ºC (Martinez-Romero et al., 2006) and 'Autumn Royal' table grapes treated with 33% aloe gel stored at 2 ºC (Castillo et al., 2010).

3.5 Percentage Disease index (PDI)

PDI was used to observe the effectiveness of coated material on fruit in retarding fruit disease. No disease signs were observed until 1 week after the beginning of storage period. This was due to the anti-microbial potentiality of coated materials. At 12 days storage 100% disease incidence was observed in controls, whereas for AG and PLEAG coated fruits disease incidence was only 27% and 13%, respectively (Table 3). Aloe gel and papaya leaf juice contain bioactive agents which mainly serve to prevent papaya fruit disease (Bautista-Baños, Hernández-López, Barrera-Necha, & Bermúdez-Torres, 2000; Habeeb et al., 2007). Aloe gel-based coating also retard microorganism proliferation

Table 3: Effect of coatings on ascorbic acid (AA) content and percentage disease index (PDI) of papaya

	PDI			AA (mg/100 g)		
Period	**Control**	**AG**	**PLEAG**	**Control**	**AG**	**PLEAG**
0 d	–	–	–	59.00	64.70	93.80
4 d	–	–	–	62.26	87.49	103.40
8 d	60% (>75%)	10% (<15-<25%)	5% (<15%)	61.10	86.55	107.07
12 d	100% (>75%)	27% (>15-<25%)	13% (<15%)	**	96.87	120.20

** Indicates complete damage of fruits

– Indicates no disease

Table 4: Effect of coatings on size value and firmness of Papaya

	Size (mm)			Firmness		
Period	**Control**	**AG**	**PLEAG**	**Control**	**AG**	**PLEAG**
0 d	86.97 ± 1.19^{ab}	87.61 ± 2.63^{b}	84.60 ± 0.83^{a}	6 ± 0.00^{a}	6 ± 0.00^{a}	6 ± 0.00^{a}
4 d	82.31 ± 1.97^{a}	86.66 ± 1.97^{b}	87.31 ± 2.17^{b}	3.2 ± 0.44^{a}	4.2 ± 0.44^{b}	5.6 ± 0.54^{c}
8 d	69.99 ± 1.36^{a}	86.73 ± 1.72^{b}	86.12 ± 0.76^{b}	1.5 ± 0.70^{a}	3.25 ± 0.50^{b}	3.60 ± 0.54^{b}
12 d	**	83.97 ± 1.47^{a}	84.15 ± 0.64^{a}	**	3 ± 0.00^{a}	3.2 ± 0.54^{a}

** Indicates complete damage of fruits

Significance tests were carried out during storage period. Mean ± S.D. in a row followed by different letters are significantly ($p \leq 0.05$) different (DMRT).

(AG: Aloe gel coated fruits; PLEAG: Papaya leaf extract incorporated Aloe gel coated fruits)

Table 5: Ripening condition of papaya

	Ripening of papaya Peel Color (%)														
	Control					**AG**					**PLEAG**				
Period	BG	GSLYS	GSWYS	CYSGA	CHAYS	BG	GSLYS	GSWYS	CYSGA	CHAYS	BG	GSLYS	GSWYS	CYSGA	CHAYS
0 d	100					100					100				
4 d		40	60			100					100				
8 d				60	40	80		20			80	20			
12 d	**	**	**	**	**	60		40			40	20	40		

BG=Bright Green, GSLYS=Green Skin with Light Yellow Stripe, GSWYS= Green Skin with Well-defined Yellow Stripe, CYSGA = Clearly Yellow Colored Skin with some Green Areas, CHAYS=Characteristic Yellow colored Skin.

** Indicates complete damage of fruits

(AG: Aloe gel-coated fruits; PLEAG: Papaya leaf extract incorporated Aloe gel-coated fruits)

Table 6: Overall appearance of papaya

Treatments	Appearance				
	Storage Periods	Color	Flavor	Firmness	Remarks
Control	0 days	BG(5)	Satisfactory	Very Firm	Good
	4 days	GSLYS+GSWYS	Satisfactory	Slightly soft	Good
	8 days	CYSGA+CHAYS	Unsatisfactory	Very soft	Inferior
	12 days	**	**	**	**
AG	0 days	BG	Satisfactory	Very firm	Good
	4 days	BG	Satisfactory	Moderately firm	Good
	8 days	BG+GSWYS	Satisfactory	Slightly soft	Good
	12 days	BG+GSWYS	Satisfactory	Slightly soft	Good
PLEAG	0 days	BG	Satisfactory	Very firm	Good
	4 days	BG	Satisfactory	Very firm	Good
	8 days	BG+GSLYS	Satisfactory	Moderately firm	Good
	12 days	BG+GSLYS+GSWYS	Satisfactory	Slightly soft	Good

** Indicates complete damage of fruits.

BG=Bright Green, GSLYS=Green Skin with Light Yellow Stripe, GSWYS= Green Skin with Well-defined Yellow Stripe, CYSGA = Clearly Yellow Colored Skin with some Green Areas, CHAYS=Characteristic Yellow colored Skin.

in sweet cherries (Martinez-Romero et al., 2006) and table grapes (Valverde et al., 2005).

3.6 Ascorbic acid (AA) content

Table 3 shows that control fruits initially contained 59 mg AA, while AG and PLEAG coated fruits contained 64.7 and 93.8 mg AA, respectively. This variance in ascorbic acid content of fruits was due to differences in light intensity obtained during growth on the plant. The coated fruits were exposed to more light intensity during growth for which they contained higher AA than the control fruits. This statement is supported by Harris (1975).

Over time the ascorbic acid content of coated and uncoated fruits increased with the highest value (120.2 mg) found in PLEAG-coated fruits at 12 days storage (Table 3). This was due to low oxygen permeability of coating which delayed the deteriorative oxidation reaction of AA content (Ayranci & Tunc, 2003). This was also found by Howard and Hernandez-Brenes (1998). Sumnu and Bayindirli (1994) reported that coating reduces respiration of the fruits and retains the ascorbic acid in the fruits.

3.7 Size value

The mean size value of AG (86.73 mm) and PLEAG (86.12 mm) coated fruits was significantly ($p \leq 0.05$) different from control fruits (69.99 mm) after 8 days storage (Table 4). Water loss causes shrinkage and loss of weight. Size was measured to determine the effect of coated material on fruit shrinkage. There was maximum reduction (16.98 mm) in size of control fruits and minimum reduction in the PLEAG coated fruits (0.45 mm) after 8 days storage. This was due to the greater water loss in control fruits and less loss in coated fruits.

3.8 Firmness

The initial firmness values were similar for both uncoated (control) and coated fruits ($p \leq 0.05$). After 8 days storage, the control fruits began to show a gradual loss of firmness compared to the coated fruits. At 12 days of storage, control fruits decayed and the coated fruits were slightly soft but did not differ significantly ($p \leq 0.05$). This indicated that the ripening of coated fruits was delayed by delaying softening (Table 4). Loss of texture is one of the main factors limiting quality

and post-harvest shelf life of fruits and vegetables. Fruits softening occurs considerably during ripening which is mainly as a result of degradation of the middle lamella of the cell wall of cortical parenchyma cells (Perkins-Veazie, 2010). Changes in cell wall structure and in their composition are mainly due to the combined action of enzymes including hydrolases, particularly polygalacturonase (PG), pectinestarage (PE), β-Galactosidase (β-Gal), pectate lyase (PL) and cellulose (Cel) (Brummell & Harpster, 2001).
Treatment with AG and PLEAG significantly reduced the loss of firmness and this can be associated with less weight loss. A similar result was found in coated strawberries (Del-Valle, Hernandez-Munoz, Guarda, & Galotto, 2005) and cherries (Alonso & Alique, 2004). In addition, Aloe gel has a role in the reduction of activity of PG, PE and β-Gal enzymes responsible for fruit softening and also maintains the pectin (Martinez-Romero et al., 2006).

3.9 Peel color change

Color is one of the most important visual attributes of papaya. The bright green color of control and coated fruits changed to yellow color after storage period. Complete yellowness was found after 8 days storage of control fruits, whereas green skin with well defined yellow stripe was found at 12 days storage period of coated fruits (Table 5).
Visual assessment is the first impression and a key feature in the choice of the fruit. Surface color of papaya is one of the most important criteria in determining ripening of papaya. Color retention of coated fruits was due to the delay in ripening of coated fruits. The modified atmosphere created by the edible coating material retarded the ethylene production rate, therefore, delaying ripening, chlorophyll degradation and carotenoid synthesis thus ultimately delaying color change of fruits (Carrillo-Lopez, Ramirez-Bustamante, Valdez-Torres, Rojas-Villegas, & Yahia, 2000; Hoa, Ducamp, Lebrun, & Baldwin, 2002).

3.10 Overall appearance of papaya

The overall appearance of control papayas (a combination of “green skin with light yellow stripe” and “green skin with well defined yellow stripe”) was acceptable up to 4 days but it became inferior from the 6^{th} day onward (Table 6). The flavor of fruits was found to be satisfactory and firmness was slightly soft. However, after the 6^{th} day the papayas started to deteriorate as they ripened fully and peel color changed to a combination of “clearly yellow colored skin with some light green areas” and “characteristic yellow skin”. At 8^{th} day their firmness became very soft and flavor was completely unsatisfactory.
In the case of AG-coated fruits, the color was “bright green” until the 4^{th} day of storage, but from the 6^{th} day they started to show a color combination of “bright green” and “green skin with well defined yellow stripe”. At 8^{th} day their firmness became slightly soft and even at 12^{th} day they were also slightly soft. During storage intervals (0, 4, 8 and 12 days) their flavor was found to be satisfactory. In the case of the PLEAG-coated fruits, the color was “bright green” until 4^{th} day and at 8^{th} day color became a combination of “bright green” and “green skin with light yellow stripe”. At 12^{th} day it became a combination of “bright green”, “green skin with light yellow stripe” and “green skin with well defined yellow stripe”. Their firmness was moderate at 8^{th} day and at 12^{th} day they were slightly soft. Like AG-coated papayas, the flavor of PLEAG-coated fruits was satisfactory over the whole storage period. The AG- and PLEAG-coated papayas started to decay at 16^{th} day with unpleasant flavor.

4 Conclusions

Fruits face tremendous loss due to old-fashioned preservation practice and ignorance about preservation strategies. Chemical preservatives which are now used widely can have dangerous effects on health such as various types of cancers, kidney and liver damage, etc. This work revealed that the AG- and PLEAG-coated fruits acquired an extended shelf life and the coatings preserved the valuable attributes of the fruit.

This work recommends Aloe gel as a successful biopreservative and a useful alternative to synthetic preservative. Having no adverse effect on fruits, environment and consumers health, *Aloe vera* gel could easily and safely be applied to papaya fruits. The application of edible coatings could easily be integrated in the current handling system. Furthermore, as demonstrated, incorporation of papaya leaf juice to the Aloe gel as an anti-fungal natural additive makes Aloe gel more effective and convenient in controlling fungus growth on papaya.

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