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Effect of *Aloe vera* (*Aloe vera* (l.) Burm. F.) based edible coating compared to beeswax coating on shelf life and quality attributes of tomato (*solanum lycopersicum* l.) at cold room

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Abstract

Tomato (*Solanum lycopersicum* L.) is an important cash crop and a seasonal crop with high nutritional and antioxidant properties where the surplus production is not preserved due to inadequate application of postharvest techniques in Sri Lanka. Tomato is highly perishable which has a storage life of seven days at ambient condition. There is a high production of tomato during the time of harvest. But postharvest processing and preservation techniques are inefficient. Therefore, tomato fruits spoil very early due to lack of usage for preservation and processing techniques. 'Bathiya' tomato variety was used in this study to evaluate the effect of *Aloe vera* (*Aloe vera* (L.) Burm. F.) based edible coating and commercial beeswax coating together with passive modified atmosphere packaging (MAP) on shelf life and quality attributes of tomato at cold room conditions (13±1 °C, RH ≈ 65%-85%). Variations in percentage weight loss, percentage disease incidence, ascorbic acid content, lycopene content, pH, firmness, titrable acidity, total soluble solid content were evaluated throughout the storage period at different time intervals. It was found that, *A. vera* edible coating was significantly effective in delaying disease incidence and increase in lycopene content compared to beeswax coating. However, beewax coating was significantly effective in delaying ripening with regards to ascorbic acid content and titratable acidity compared to *A. vera* coating. Further, percentage weight loss, pH, firmness were significantly affected by both edible coatings. Total soluble solid (TSS) content was not affected by edible coatings. Further, *A. vera* edible coating is more cost effective than beeswax coating. However, *A. vera* and beeswax coating with passive MAP can be used to extend the shelf life of tomato up to 49 days with better quality attributes while the non-coated tomatoes with passive MAP extended the shelf life only up to 35 days at cold room conditions.

Keywords: Ascorbic acid, Edible coating, Firmness, Lycopene, Modified atmosphere packaging

Introduction

Tomato (*Solanum lycopersicum* L.) has the third highest production among globally produced horticultural fruits and vegetables due to its nutritional and economic importance (Tan *et al*., 2010). Tomato is one of the most widely cultivated vegetable crop in Sri Lanka. In Sri Lankan context, it is an important cash crop for medium scale commercial farmers (Priyankara *et al*., 2017). It has a high demand in both local and foreign markets. According to custom reports in 2016, the total foreign exchange from fresh tomato was 7.5 million rupees. Demand for tomato in Sri Lanka is all around the year due to its versatile use, especially in local dishes in both fresh and processed forms (Alwis *et al*., 2008). Tomato provides a wide variety of nutrients that are beneficial for health and well-being. An average tomato can provide 40% of the adult recommended daily allowances of 60 mg of phytonutrients (Charanjeet *et al*., 2004). Tomatoes contain many polyphenolic compounds that protect the body from oxidative stress. These compounds act as free radical scavengers, singlet oxygen quenchers, metal chelators and enzyme inhibitors for the active oxygen species (Di-Mascio *et al*., 1989). Tomato is the main dietary source of lycopene, which is a red color carotenoid and a non provitamin Rodriguez-Bustamante and Sanchez, 2007) with antioxidant properties (Arab and Steck, 2000). Generally lycopene is stable to processing when it is present in the plant tissue matrix (Story *et al*., 2010).

Major losses in the quality and quantity of fresh vegetable and fruit products occur in between harvest and consumption. Quality of fresh tomatoes is considered by consumers in relation to firmness, color and taste, which are related to ripeness and shelf life (Brooks *et al*., 2008). Shelf life of tomato at room temperature varies from 4 to 8 days depending on storage conditions. This short period of shelf life highly limits the commercial transport of tomato for a long distance (Benhabiles *et al*., 2013). Edible coatings are used in fresh fruits and vegetables to reduce the deleterious effects on intact tissues. Created modified atmosphere reduces weight loss during transport and storage (Baldwin, 1994).

Modified Atmosphere Packaging (MAP) is a useful technology to extend the shelf life of fresh agricultural and horticultural produce. In MAP, fruit or vegetable is stored in a modified atmosphere usually consisting of reduced O_2 and increased CO_2 concentrations. The modified atmosphere reduces the rates of respiration and ethylene production. It helps to retard the physiological, pathological, and physical deteriorative processes occurring in the product (Yam and Lee, 1995). This study was carried out

to evaluate the effect of *Aloe vera* (*Aloe vera* (L.) Burm. F.) based edible coating and commercial Beeswax coating together with passive modified atmosphere packaging (MAP) on shelf life and quality attributes of tomato variety 'Bathiya' at cold room conditions (13±1 °C, RH ≈ 65%-85%).

Materials and Methods

Sample collection

Tomato variety Bathiya was harvested at the maturity stage of 50% from an outdoor farm, Gannoruwa maintained by Horticultural Crop Research and Development Institute at Gannoruwa. Selected fruits were washed with potable water and allowed for air-drying. Sampling was done for each treatment by considering physical growth parameters such as peel color and size. Initial weight of each selected fruit was measured.

Preparation of *Aloe vera* coating solution

Aloe vera coating solution was prepared according to Maughan (1984) and Sophia *et al*. (2015) with slight modifications. Mature leaves of the species of *Aloe vera* (L.) Burm. F. (authenticated by National Herbarium, Peradeniya, Sri Lanka) were obtained and outer cortex was removed. Colorless hydro parenchyma was ground using mortar and pestle and filtered to remove fiber using muslin cloth to obtain the extract of fresh *Aloe vera* gel. Extracted gel was pasteurized at 70 °C for 20 minutes and allowed to cool down until it reaches ambient temperature. For the stabilization of the gel, 10 g L^{-1} of carboxy methyl cellulose was added. 4.5 g L^{-1} of ascorbic acid and 4.5 g L^{-1} of citric acid were added to adjust pH to 4.0.

Preparation of bee wax coating solution

4.0 g of bee wax was dissolved in 200 mL of water and ethanol mixture (3:1) at 70 °C. Then it was stirred for 10 minutes using a magnetic stirrer to obtain 2% beeswax coating solution according to Abbasi *et al*. (2011).

Experimental treatments and design

Cleaned, air dried tomatoes were divided into three groups and for one group of tomatoes, *Aloe vera* coating solution was sprayed within 5 sec. on the outer surface and left for air drying at 26 ±1 °C temperature and 55% relative humidity for ten min. After drying (i.e. until no more stickiness), second spraying was done and left for air drying as described above, followed by passive MAP. Methodology followed in this experiment was described by Valverde *et al*. (2005) According to Atieno *et al*. (2019) there was no significant ($p \leq 0.05$) difference between the two different coating applications of dipping

and spraying on the cassava root samples which the study aimed at determining the most efficient coating application method on the cassava postharvest quality. So another group of tomatoes were dipped for two sec. in prepared beeswax coating solution and left for air drying as described above, followed by passive MAP. Last group was packed in passive MAP without coating. Passive MAP was done using 100 gauge LDPE (10 cm × 15 cm) bags and sealed with controlled number of pin holes. All the samples were stored at cold room condition (13±1 °C, RH ≈ 65%-85%).

Data collection

Percentage weight loss

Laboratory analytical balance (TCM 128/13-5095) was used to measure weight of each tomato fruit. Percentage weight loss was calculated using the following equation (Yaman and Bayoindirli, 2002).

Disease incidence

Fruits without any signs of disease were used in this study. Disease incidence was determined by visual inspection of the external appearance of the rotting surface of the fruit and fruit rot using the scale given by Priyankara *et al*. (2017) and shown in Table 1.

Table 1. Rating scale of disease index

Scale	Description
0	No disease at all
1	Slight (1-10%)
2	Moderate (11-20%)
3	High (20-30%)
4	Disease (>30%)

Ascorbic acid content

Ascorbic acid content was determined at three week interval using 2, 6-Dichlorophenolindophenol titrimetric method. Ascorbic acid standard was prepared by dissolving 100 mg of L. ascorbic acid powder in 100 ml of 3% HPO_3. Ten ml of the Ascorbic acid solution was diluted to 100 mL with 3% HPO_3. Dye was prepared by dissolving 50 mg of 2, 6-dichlorophenolindophenol (DCPIP)/sodium salt in 150 mL of hot distilled water with 42 mg of sodium bicarbonate already dissolved in it. Distilled water was added up to 200 ml. Dye factor was obtained by titrating 5 mL of ascorbic acid standard and 5 mL of 3% HPO_3 with 2,6-DCPIP.

$$\text{Dye Factor} = \frac{0.5}{\text{Titre Value}}$$

Titre value = volume of 2, 6-DCPIP required

A tomato sample of 2 g was chopped with 20 mL of 3% HPO_3 and filtered. Five milli liter of prepared solution was titrated with 2, 6-DCPIP solution in the burette in triplicate. Ascorbic acid content was determined using the following equation and expressed in mg of ascorbic acid per 100g (Freed, 1966).

$$\text{Ascorbic acid (\%)} = \frac{\text{titre} \times \text{dye factor} \times \text{volume made up}}{\text{Aliquote of extract taken weight or volume of sample}} \times 100$$

Lycopene content

Lycopene content was determined by low volume hexane extraction method at three-week interval. A tomato sample of 0.6 g from each treatment was taken into a 40 mL amber screw top vial containing 5 mL of 0.05% butylated hydroxy toluene in acetone and 5 mL of 95% ethanol and 10 mL of hexane, separately. It was stirred in a magnetic stirrer and then in an orbit shaker on ice at 180 rpm for 15 minutes. Then, 3 mL of deionized water was added and it was shaken for 5 minutes on ice. Prepared samples were left at room temperature for 5 minutes for phase separation. Absorbance (A_{503}) of upper hexane layer was measured in 1 cm path length quartz cuvette at 503 nm. A cuvette with hexane was used as the blank. Absorbance at 503 nm and sample weight was taken to determine the lycopene content using following equation (Fish *et al*., 2002).

$$\text{Lycopene (mg kg}^{-1}) = \frac{(A503 \times 0.0312)}{\text{Tissue weight}}$$

pH

Samples representing each treatment were taken separately and chopped using a mortar and pestle. Juice was separated by filtering through a muslin cloth. pH was determined the filtered juice using a digital pH meter.

Firmness

Firmness of fruits was tested using fruit pressure tester (FT 327, Taiwan) expressed as force required (1 kg) to complete 1 cm penetration (Jayathunge *et al*., 2011).

Total soluble solid content

Pulped sample extract was filtered through a muslin cloth to separate juice and pulp. A drop of juice was placed on the prism of the hand held refractometer (0-30 °Brix)

and measured the total soluble solid content of each sample (Majidi *et al*., 2011).

Titrable acidity

Titrable acidity was determined by AOAC (1994) method. Tomato samples were chopped by using a mortar and pestle. Extract was filtered through a muslin cloth to separate the pulp. One ml of extract was diluted with 9 mL of distilled water. Prepared samples were titrated with 0.1 M NaOH in the presence of phenolphthalein indicator and results were expressed as % of citric acid. Titrable acidity was determined at three week interval.

$$\text{Citric acid (\%)} = \frac{T \times N \times V_1 \times E}{V_2 \times W} \times 100$$

T= Titre, N= Normality of NaOH, V_1= Volume made up, E= Equivalent weight of citric acid, V_2= Volume of sample taken for estimation, W= Weight of sample

Cost analysis

Production cost for 1 kg of tomato coating was calculated according to the material cost at the time of research period..

Statistical analysis

All the quality attributes were measured in triplicates for each treatment. Collected data were statistically analyzed by one way ANOVA using Minitab® 19.1 (64-bit) statistical software. Mean comparison was done by Turkey comparison.

Results and Discussion

Physical and chemical parameters of tomatoes at initial stage

Means of initial data of both physical and chemical parameters of selected tomatoes (var. Bathiya) are given in the Table 2.

Table 2. Physical and chemical parameters of tomatoes at the initial stage

Parameter	Unit	Mean	Standard error	Range
Weight	g	81.49	3.06	76.09-86.71
Firmness	kg	2.04	0.17	1.75-2.32
TSS	°Brix	3.80	0.80	2.8-5.4
pH		4.19	0.06	4.12-4.32
Titrable acidity	% Citric acid	0.51	0.00	0.51-0.57
Ascorbic acid content	mg 100 g^{-1}	19.44	0.1	19.05-20.24
Lycopene content	mg kg^{-1} tissue	3.01	0.36	2.16-3.86

Variation of the percentage weight loss

According to the Table 3, % weight loss of all the samples increased gradually with storage period. Initially at day 7 there was no significant difference ($p>0.05$) among three treatments and at 14 days significantly ($p<0.05$) higher % weight loss was shown in non-treated sample and which continued up to 35 days and then those tomatoes were rotten and discarded. Percentage weight loss of *Aloe vera* and Beeswax treatments were increased up to 35 days and samples were kept up to 48 days without significant difference between both the treatments. There was no significant difference ($p>0.05$) of % weight loss between the *Aloe vera* and beeswax coated treatments from the first day to the 48th day of storage. There was a significant difference ($p<0.05$) and comparatively higher weight loss in non-coated treatment than coated samples. Thus, edible coatings helped to extend the shelf life of tomato by controlling the rate of respiration and preventing moisture loss. Hyun *et al*. (1994) indicated that tomatoes coated with corn-zein has significantly reduced weight loss ($p<0.05$) compared to non-coated tomatoes during the storage at 21°C and shelf life of coated tomatoes were 15 days while the non-coated had only 9 days.

Variation of disease incidence

Fruits without any signs of disease were used in this study. At 35 days of the storage, uncoated samples were discarded due to perceptible quality loss. Tomatoes with edible coatings remained for 49 days at cold room condition. Table 3 indicates that there was no significant difference ($p>0.05$) among differently treated tomatoes up to 21st day of storage. Thus, low temperature (13±1 °C, RH ≈ 65%-85%) and low oxygen levels must have reduced the rate of microbial growth. After 28 days of storage, there was a significantly lower level ($p<0.05$) of fruit rot symptoms/ disease incidence in *Aloe vera* coated samples compared to both none coated and beeswax coated samples up to 48 days. Therefore, *Aloe vera* has specifically controlled the disease occurrence through its antimicrobial activity. *Aloe vera* gel has good antibacterial activity against some food borne pathogenic microorganisms such as *Bacillus cereus, Salmonella typhimurium, Escherichia coli*, and *Klebsialla pneumonia* (Shelton, 1991). A novel edible coating has been developed by Valverde *et al.* (2005) (SP patent filed 200302937) based on *Aloe vera* gel to preserve cv. 'Crimson' seedless table grapes by maintaining the quality, enhancing self-life and safety. Shelf life of uncoated control samples was 7 days at 1 °C and 4 days at 20 °C. Coated grape samples were reported to have a shelf life of 35 days at 1 °C with significantly delayed quality losses.

Table 3. Percentage weight loss and percentage disease incidence of tomatoes at cold room (13 ±1 °C and 65-85% RH)

Days after storage	Percentage weight loss at cold room			Disease incidence at cold room		
	MAP	MAP+AV	MAP+BW	MAP	MAP+AV	MAP+BW
7	0.32±0.04^{a}	0.22±0.04^{a}	0.30±0.050^{a}	0.40±0.31^{a}	0.00±0.00^{a}	0.00±0.00^{a}
14	0.72±0.05^{a}	0.42±0.02^{c}	0.47±0.08^{bc}	0.60±0.51^{a}	0.00±0.00^{a}	0.20±0.25^{a}
21	1.23±0.19^{a}	0.67±0.04^{c}	0.79±0.03^{bc}	1.40±0.51^{a}	0.20±0.25^{a}	0.60±0.51^{a}
28	1.93±0.06^{a}	0.86±0.07^{c}	0.99±0.07^{c}	2.20±0.62^{ab}	0.60±0.51^{b}	1.00±0.40^{ab}
35	2.23±0.10^{a}	1.11±0.05^{b}	1.35±0.09^{b}	3.20±0.47^{ab}	1.00±0.40^{c}	1.80±0.47^{bc}
42		1.64±0.15^{a}	1.92±0.21^{a}		1.00±0.40^{c}	3.60±0.31^{a}
48		2.51±0.30^{a}	3.16±0.35^{a}		1.40±0.31^{c}	4.00±0.00^{a}

Mean with the same letters within a row are not significantly different ($p>0.05$). MAP-modified atmosphere packaging, AV-Aloe vera, BW-Bees wax coated

Variation of the Ascorbic acid content

Emese and Nagymate (2008) reported that the stability of ascorbic acid decreases with increase in temperature and pH. During oxidation of ascorbic acid in processing a considerable quantity is lost. Ascorbic acid decreases gradually during storage, especially at temperature above 0 °C. Table 4 indicates that there was no significant difference ($p>0.05$) in ascorbic acid content in all three samples after 21 days of storage. However, ascorbic acid content of beeswax coated tomato (17.02±1.65 mg 100 g^{-1}) was significantly higher ($p<0.05$) than the *Aloe vera* coated tomatoes (14.22±0.51 mg 100 g^{-1}) at the 42nd day of storage. Therefore, beeswax coating has significantly reduced ($p<0.05$) the rate of ripening process than the *Aloe vera* edible coating with regards to ascorbic acid content.

Variation of the lycopene content

The table 4 indicates that there was significantly higher ($p<0.05$) lycopene content in non-coated tomato, which indicates a higher ripening rate at 21st day of storage. However, *Aloe vera* coated tomato had a significantly lower ($p<0.05$) lycopene content than non-coated and beeswax coated tomatoes indicating lower rate of ripening at 21st day of storage. After 42 days of storage also, there was a significantly lower ($p<0.05$) lycopene content compared to beeswax coated tomato. Therefore, *Aloe vera* coating had significantly reduced the rate of tomato ripening throughout the storage period compared to non-coated and beeswax coated tomatoes. Athmaselvi *et al*. (2013) reported that *Aloe vera* based coating has significantly delayed the ripening rate of tomato with regards to lycopene content of 1.39±0.01 µg g^{-1} after 20 days of storage at ambient condition while the non-coated tomato had 42.09±0.24 µg g^{-1} of lycopene content.

Table 4. Ascorbic acid contents and lycopene contents of tomatoes stored at cold room (13 ±1 °C and 65-85% RH)

Sample	Ascorbic acid content (mg 100 g^{-1}) after 21 days	Ascorbic acid content (mg 100 g^{-1}) after 42 days	Lycopene content (mg kg^{-1}) after 21 days	Lycopene content (mg kg^{-1}) after 42 days
MAP	17.05±0.95 ^{ab}		10.48±0.07 ^{a}	
MAP+BW	19.11±0.51 ^{a}	17.02±0.57 ^{a}	8.37±0.07 ^{b}	13.56±0.18 ^{a}
MAP+AV	17.08±0.66 ^{ab}	14.22±0.29 ^{b}	7.14±0.25 ^{c}	10.34±0.65 ^{b}

Means with the same letters within a column are not significantly different ($p<0.05$). Abbreviations are referred under footnote of Table 3.

(Initial Ascorbic acid content and lycopene content of tomato are 19.44±0.1 mg 100 g^{-1} and 3.01±0.36 mg kg^{-1} respectively).

Variation of the pH

Shahid and Abbasi (2011) stated that increase in pH is due to high rate of metabolic activities. Therefore, acidity decreased but pH increased. As shown in Table 5, pH increased gradually with storage period. However, the pH of non-coated tomatoes were significantly higher ($p<0.05$) than *Aloe vera* and beeswax coated samples throughout the storage time. Therefore, both *Aloe vera* and beeswax coatings had delayed the rate of ripening. However, there was no significant difference ($p>0.05$) among *Aloe vera* and beeswax coated samples in pH value throughout the storage period except day 42.

Variation of fruit firmness

Yaman and Bayoindirli (2002) described that firmness is retained due to the retard degradation of insoluble protopectins, into pectic acid and pectin, which are highly soluble. As shown in Table 5, firmness had gradually reduced with storage time in all the three samples. At the 35th day, there was a significantly lower ($p<0.05$) firmness in non-coated tomato when compared with *Aloe vera* and bee wax coated tomatoes. However, there was no significant difference ($p>0.05$) among *Aloe vera* and beeswax coated tomatoes throughout the storage period in firmness. Therefore, coating was the most effective treatment for retardation of softening of harvested tomatoes compared to the control. Martinez-Romero *et al*. (2006) reported that *Aloe vera* coated sweet cherries maintained firmness (1.38±0.05 N mm^{-1}) at the harvest while the control had enhanced softening (1.02±0.03 N mm^{-1}) at the end of 16 days at 1ºC.

Table 5. Variation of pH and firmness of tomatoes stored at cold room (13 ±1 °C and 65-85% RH)

Days	pH			Firmness (kg)		
	MAP	MAP+BW	MAP+AV	MAP	MAP+BW	MAP+AV
7	2.03±0.01^{a}	1.93±0.04^{c}	1.91±0.01^{c}	2.0±0.09^{a}	2.14±0.05^{a}	2.05±0.02^{a}
14	2.06±0.01^{ab}	1.98±0.04^{c}	1.95±0.02^{c}	1.74±0.02^{b}	1.98±0.11^{a}	2.0±0.110^{a}
21	2.1±0.005^{ab}	2.02±0.01^{c}	2.0±0.002	1.48±0.06^{bc}	1.59±0.05^{abc}	1.66±0.08^{a}
28	2.13±0.005^{a}	2.05±0.01^{cd}	2.03±0.01^{d}	1.24±0.06^{bc}	1.4±0.05^{ab}	1.5±0.05^{a}
35	2.17±0.01^{a}	2.09±0.01^{cd}	2.06±0.01^{d}	0.69±0.17^{b}	1.18±0.09^{a}	1.19±0.57^{a}
42		2.14±0.01^{a}	2.1±0.01^{b}		1±0.05^{a}	1.01±0.05^{a}
49		2.17±0.01^{bc}	2.13±0.03^{c}		0.68±0.05^{a}	0.72±0.11^{a}

Means with the same letters within a row are not significantly different ($p<0.05$). Abbreviations are referred under footnote of Table 3.

Variation of total soluble solid content

Moneruzzaman *et al*. (2008) stated that increase in total soluble solid content is due to the hydrolysis of starch into sugar. As shown in Table 6, there was no significant difference ($p>0.05$) among differently treated samples until the 28th day of storage. But at the 35th day, there was a significantly lower ($p<0.05$) TSS content in non-coated tomato. According to Torgul and Arslan (2004), significant reduction of TSS in non-coated sample was due to break-up of carbohydrates and pectin, partial hydrolysis of protein, and decomposition of glycosides into subunits during respiration. However, there was no significant difference ($p>0.05$) in TSS content among *Aloe vera* and beeswax coated tomatoes throughout the storage period. However, TSS content has gradually increased with storage time due to ripening of tomatoes. But, TSS content was not significantly affected ($p>0.05$) by edible coatings.

Table 6. Variation of TSS (ºBrix) content of tomatoes stored at cold room (13 ±1 °C and 65-85 % RH)

Sample	7 days	14 days	21 days	28 days	35 days	42 days	49 days
MAP	4.50±0.05^{a}	4.53±0.02^{b}	4.63±0.02^{a}	4.73±0.02^{a}	4.56±0.02^{b}		
MAP+AV	4.66±0.02^{a}	4.66±0.06^{ab}	4.73±0.02^{a}	4.73±0.06^{a}	4.80±0.00^{a}	4.63±0.02^{a}	4.56±0.02^{a}
MAP+BW	4.60±0.05^{a}	4.56±0.02^{ab}	4.66±0.02^{a}	4.70±0.05^{a}	4.73±0.02^{a}	4.60±0.00^{a}	4.50±0.05^{a}

a, b, Means with the same letters within a row are not significantly different ($p<0.05$). Abbreviations are referred under footnote of Table 3.

Variation of titrable acidity

Citric acid and malic acid levels are high in tomatoes (Davies and Maw, 1972). During ripening, these organic acids are used in the enzymatic reactions of respiration mechanism. Therefore, reduction in the titrable acidity is occurred. However, titrable acidity of all the samples have greatly reduced compared to the initial sample and has decreased with the storage time. As shown in Table 7, titrable acidity of beeswax coated tomatoes was significantly higher at both instances of 21st day and 42nd day compared to both none coated and *Aloe vera* coated tomatoes. Therefore, beeswax coating has delayed the ripening process with regards to titrable acidity.

Table 7. Variation of titrable acidity of tomatoes stored at cold room (13 ±1 °C and 65-85% RH)

Sample	TA (% citric acid) after 21 days	TA (% citric acid) after 42 days
MAP	0.26±0.01^{b}	
MAP+AV	0.25±0.00^{b}	0.19±0.00^{b}
MAP+BW	0.38±0.00^{a}	0.27±0.01^{a}

Means with the same letters within a column are not significantly different ($p<0.05$). Abbreviations are referred under footnote of Table 3.

Cost analysis

When consider the cost effectiveness, price for the coating material to apply for 1 kg of tomato for *Aloe vera* based coating material and bee wax coating material was Rs. 4.30 and Rs. 24.33, respectively (Table 8, Table 9). Cost benefit of coating with *Aloe vera* coating material than beeswax coating material is Rs.17.08. Therefore, *Aloe vera* edible coating is more economical in extending the shelf life of tomatoes while maintaining good quality.

Table 8. Production cost of *Aloe vera* coating material

Item	Quantity	Price (Rs.)
Aloe vera leaves	1.0 kg	90.00
CMC	10 g	8.84
Citric acid	4.5 g	1.58
Ascorbic acid	4.5 g	1.58
Other cost		10.00
Quantity of tomatoes that can be coated	26 kg	
Unit price	Per 1 kg of tomato	4.30

Table 9. Production cost of beeswax coating material

Item	Quantity	Price (Rs.)
Bee wax	20 g	30.00
Ethanol		
Other cost	250 ml	33.00
10.00		
Total cost		73.00
Quantity of tomatoes that can be coated	3 kg	
Price for coating	Per 1 kg of tomato	24.33

Conclusion

Edible coatings of *Aloe vera* and beeswax along with passive MAP extended the shelf life of tomatoes up to 49 days while the non-coated tomatoes with passive MAP had a shelf life of 35 days at cold room conditions (13±1 °C, RH ≈ 65%-85%) according to the estimated parameters. Both Edible coatings delayed the rate of ripening of tomato with regards to the percentage weight loss, pH, and firmness up to 49 days. In addition, *Aloe vera* edible coating has significantly delayed the ripening, in other words lengthen the shelf life with regards to important parameters such as disease incidence and lycopene content compared to beeswax coating. Beeswax coating has significantly delayed the ripening with regards to ascorbic acid content and titrable acidity compared to *Aloe vera* coating. However, TSS content was not significantly affected by edible coatings. According to the cost analysis *Aloe vera* coating is cost effective than bees wax coating for application of coating for 1 kg sample of tomato.

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