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Original Research

Effect of Postharvest Edible Coatings on Fruit Quality of Guava cv. Sufaid Gola under Ambient and Zero-Energy Cool Chamber Storage Conditions

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ABSTRACT

Investigations were made to evaluate the effect of different edible and chemical coatings on quality and shelf life of guava (*Psidium guajava* L.) cv. Sufaid Gola fruits stored under ambient (20 ± 3 °C) and zero energy cool chamber (ZECC) conditions (15 ± 3 °C). The fruits were subjected to different coating treatments, i.e., control (uncoated fruits, T_0), fruits coated with 1% $CaCl_2$ (T_1), 2% $CaCl_2$ (T_2), 10% *Aloe vera* gel (T_3) and 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4). The studied quality attributes included weight loss, total soluble solids (TSS), pH of fruit juice and fruit skin colour. As the storage period increased, weight loss, juice TSS and pH values significantly increased. Fruit skin colour also changed depending on the coating treatment, storage conditions and duration. Fruits stored at ZECC conditions had lower weight loss with lesser juice TSS and pH values and resulted in prolonged shelf life than ambient storage conditions. The fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid and 10% *Aloe vera* gel resulted in lower weight loss as compared to other treatments. Fruit coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid and 2% $CaCl_2$ had better shelf life with lower juice TSS and pH values as compared to other treatment combinations.

Keywords: *Aloe vera* gel, chemical treatment, cool chamber storage, guava fruits, shelf life.

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INTRODUCTION

Guava (*P. guajava* L.) is one of the world's most common fruits and belongs to the family Myrtaceae. It is considered as "the fruit of the poor man," or "the apple of the tropics" (Kosky et al., 2005) due to high nutritional value and delicious taste. The major guava producing countries are Pakistan, South Africa, India, Brazil, Egypt, Mexico, Venezuela, and Columbia (Rawan et al., 2017). It grows on an area of 62.3 thousand hectares in Pakistan and produces a yield of 512.3 thousand tons of fruits annually (Hassan et al., 2012). Guava fruit is extremely nutritious having high amounts of vitamins A, B_1 (Thiamine), B_2 (Riboflavin), and C (Ascorbic acid). The vitamin C content of guava fruit is 2–5 times that of citrus fruit (Singh, 2005). This fruit also contains a significant amount of citric, lactic, malic, oxalic, and acetic acids (Rahman et al., 2003). Fruit maturity is an important aspect for table purpose and processing due to better chemical and physical property of the fruit.

Guava fruit is climacteric in nature and is highly perishable. Its shelf-life at room temperature varies from 2 to 3 days only (Bassetto et al., 2005). Because of such perishability, fruit ripening control is important for better shelf-life after harvest. The key depreciating factors for post-harvest quality in guava are rapid loss of green colour, excessive softening, high incidence of rot and turgidity loss (Jacomino et al., 2001). Many physiological, biochemical, and compositional changes occur during fruit maturation and ripening which encourage starch degradation or other polysaccharides to produce sugars, synthesis of volatile pigment compounds, and cell wall solubilization (Jain et al., 2003). Degradation of the cell wall components results in softening of the fruit and involves increased action of enzymes such as cellulase and pectinase (Negi and Handa, 2008). Many treatments have been used to prolong shelf life of whole or fresh cut fruits including chemical treatments, edible coatings, controlled atmosphere, high and low temperature, and plastic packaging (Gonzalez-Aguilar et al., 2010). Cold storage is considered important for preserving the post-harvest quality of fresh commodities. Low temperature slows down the rate of respiration, transpiration, production of ethylene, disease incidence and senescence, thereby increasing the shelf life (Bron et al., 2005). Pre-harvest sprays of various chemicals and growth regulators have also been found effective in reducing post-harvest losses and preserving fruit quality during storage (Agrawal et al., 2014).

Aloe vera gel is used as a serum which is antibacterial, antifungal and anti-inflammatory. It is widely used in cosmetics industry for the treatment of burns and scars as well as for wound healing (Serrano et al., 2006; Amanullah et al., 2016). During the

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ripening period, post-harvest applications with calcium chloride delay fruit aging and effectively minimize post-harvest decay in many fruits and vegetables (El-Gamal et al., 2007). Calcium chloride gives better shelf life and organoleptic quality of guava fruits during low temperature storage (Kumar et al., 2014). *Aloe vera* gel coating of fresh-cut guava coupled with different additives (1.5% ascorbic acid, 2% CaCl2, and 0.2% potassium sorbate) has been reported to prolong the shelf-life and preserve fruit characteristics for a longer period (Nasution et al., 2015). *Aloe Vera* edible gel coating prevents the loss of moisture and firmness, regulates respiratory rate, delays oxidative browning, and minimizes proliferation of microorganisms in fruits such as oranges, grapes, sweet cherries, and papaya (Kumar and Bhatnagar, 2014). Further, Zero Energy Cool Chamber (ZECC) is one of the eco-friendly and low-cost post-harvest technologies that can be used to store fruits and vegetables (Dirpan et al., 2018). The aim of this study was to evaluate the shelf life and quality of guava fruits under low temperature in ZECC and ambient conditions in response to different edible coatings.

MATERIALS AND METHODS

Guava (*P. guajava* L) cv. Sufaid Gola fruits were harvested at commercial maturity stage from a private orchard located at Sharqpur during February 2018, carefully packed to avoid bruising and transported (50 km) to Postharvest Laboratory, Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan. On arrival at the laboratory, the fruits were washed with tap water and dried under ambient shelf of the laboratory. Afterwards, the fruits were separated into different lots based upon experimental layout. Experiment was conducted using completely randomized design with factorial arrangements. There were five coating treatments, two storage conditions and four replications of each treatment. The coating treatments included T_0 (control), T_1 (1% $CaCl_2$), T_2 (2% $CaCl_2$), T_3 (10% *Aloe vera* gel) and T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid). The fruits were either stored at room temperature (20 ± 3 °C) or in a zero-energy cool chamber (15 ± 3 °C).

Construction of the cooling chamber

Zero-Energy Cool Chamber (ZECC) was constructed according to the guideline given by Sunita and Dilip (2018). An upland was selected nearby water supply source and chamber was constructed using bricks with floor dimensions (165 cm x 115 cm) and 67.5 cm high double-walled leaving 7 cm cavity in between (Fig. 1). Good quality wet riverbed sand was filled in the 7 cm cavity between the two walls. A top cover of chamber (165 cm x 115 cm) was developed with bamboo frame, straw, or dry grass. A hanging over the chamber was made to protect against direct sunlight or rain or hails.

Preparation and application of coating materials

Calcium chloride solutions

To prepare 1% and 2% $CaCl_2$ solutions, 10 g, and 20 g $CaCl_2$ was weighed, respectively with an electronic balance and shifted in 1 L volumetric flasks separately. The chemical was dissolved in distilled water and volume of each flask was made up to the mark after through mixing.

Aloe vera gel solution

For the preparation of 10% solution of *Aloe vera* gel, 100 g gel was shifted in a volumetric flask followed by slowly adding distilled water to a final volume of 1 L and thorough mixing.

Aloe vera gel + Ascorbic acid solution

15% *Aloe vera* gel + 1.5% ascorbic acid solution was prepared by dissolving 15 g of ascorbic acid in small quantity of water in a 1 L volumetric flask. Then 150 g gel was added into the volumetric flask. Distilled water was added up to the mark and mixed thoroughly.

Data collection

The data were collected on different fruit quality parameters and analysed during the study to estimate the efficiency of coating materials and storage conditions to enhance the shelf life of fruits. Fruit weight loss, total soluble solids (TSS) and juice pH were measured at 3 days interval after coating treatments and storage. Skin colour of the fruit was also evaluated following the horticultural charts.

Weight loss

The weight of the fruit was measured by using an electronic weighing balance (model: HCB60.2H). Firstly, fruit weight was measured before storage and then after every three days' interval till nine days. The weight of the respective fruit in each treatment was subtracted from the initial weight to find the percentage weight loss by using the given formula.

$$\text{Percentage weight loss} = (W_1 - W_2)/W_1 \times 100$$

Figure 1: Zero-energy cool chamber (ZECC) construction at the Institute of Agricultural Sciences University of the Punjab, Lahore.

Where W_1 = Weight of fresh fruit after harvest and W_2 = Weight of fruit after storage.

Total soluble solids

The TSS of fruit juice samples was determined by using a refractometer (model: MT700). One drop of fruit juice was mounted on the refractometer lens and readings were noted.

Juice pH

pH is the negative log of hydrogen ion. It shows acidity, neutrality, or alkalinity of a sample. A pH meter (model: HI98107) was used for this purpose. The electrode of the pH meter was dipped in the juice sample and readings were noted.

Shelf life

The shelf-life of the stored fruits was determined from date of storage to the date fruits remained acceptable to the consumers. The fruits were considered totally ripened when their skin was completely yellow.

Statistical analysis

The average data were taken for each parameter and subjected to the analysis of variance (ANOVA) technique, which was followed by least significant difference (LSD) test at 5% probability. The data were analysed by applying statistical analysis program Statistix 8.1. Due to great variation, the data of each storage interval was analysed separately.

RESULTS

Weight loss

Weight loss is the difference in weight before and after the storage. Among the coating treatments, the maximum weight loss was observed in T_0 (control, uncoated fruits), followed by in T_1 ($CaCl_2$ 1%) and T_2 ($CaCl_2$ 2%). These three treatments were statistically similar. The minimum weight loss was observed in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid) and T_3 (10% *Aloe vera* gel), followed by in T_2 ($CaCl_2$ 2%) and these three coating treatments were also statistically at par. Thus, among the coating treatments, fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 10% *Aloe vera* gel (T_3) were found better in preventing the weight loss. As the storage time increased, weight loss progressively increased in the stored fruits. Significantly lower weight loss was recorded in the fruits stored for 3 days, while the higher weight loss was recorded in those stored for 9 days. Further, the fruits kept in zero energy cool chamber (15 ± 3 °C) retained more moisture with significantly lesser weight loss as compared to those stored at ambient temperature (20 ± 3 °C).

Uncoated fruits (T_0) and those coated with 1% and 2% $CaCl_2$ (T_1 and T_2, respectively) stored at ambient temperature resulted in the maximum weight loss, while those coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 10% *Aloe vera* gel (T_3) and stored in the cool chamber resulted in the minimum fruit loss, irrespective of the storage periods (Table 1).

Total soluble solid

The effect of different chemical and edible coatings on the TSS of fruits kept at room temperature and in the cooling, chamber is shown in Table 2. The maximum TSS was observed in T_0 (control, untreated fruits), whereas the minimum was recorded in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid), which were significantly different from each other. Other three treatments were in the middle, sharing statistical similarity with both the treatments. The values of TSS in guava juice showed variations with increasing trends with increase in storage time. There was non-significant change in the TSS when fruits were stored for 3 days but after that the TSS of fruit juice significantly increased being the maximum after 9 days of storage. Fruits stored in the cool chamber had significantly lower juice TSS than of those stored at room temperature.

Untreated fruits (T_0) and those treated with 1% and 2% $CaCl_2$ (T_1 and T_2, respectively) and 10% *Aloe vera* gel when shelfed at room temperature resulted in significantly higher juice TSS values. On the other hand, fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4), 2% $CaCl_2$ (T_2), 10% *Aloe vera* gel (T_3) and 1% $CaCl_2$ (T_1) when stored in the cool chamber resulted in significantly lower juice TSS values. At day 3 of storage, the

Table 1: Physiological weight loss in guava fruits treated with coating materials and stored under ambient and ZECC conditions.

Treatments	Storage cond.	Weight loss (%)				
		Day 3	Day 6	Day 9	Mean	Mean of treatments
T_0 (Control)	AT	5.93 a	14.97 a	23.68 a	14.86 a	13.95 a
	ZECC	5.40 bc	13.43 c	20.31 c	13.05 cd	
T_1 (1% $CaCl_2$)	AT	5.86 ab	14.83 a	22.78 ab	14.49 ab	13.61 a
	ZECC	5.10 cd	12.84 d	20.26 c	12.73 cd	
T_2 (2% $CaCl_2$)	AT	5.81 ab	14.26 b	21.46 bc	13.84 abc	13.02 ab
	ZECC	4.69 de	11.91 e	20.00 c	12.20 d	
T_3 (10% *Aloe vera* gel)	AT	5.63 ab	13.95 bc	21.43 bc	13.67 bc	11.83 b
	ZECC	4.55 e	9.57 f	15.83 d	9.98 e	
T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid)	AT	5.50 abc	13.64 c	20.31 c	13.15 cd	11.49 b
	ZECC	4.37 e	9.34 f	15.74 d	9.82 e	
Means of storage days		5.28 c	12.87 b	20.18 a	-	-
Means of storage conditions			AT		14.00 a	
			ZECC		11.56 b	

AT = ambient temperature, ZECC = zero energy cool chamber.

Table 2: Changes in total soluble solids (TSS) of guava fruits treated with coating materials and stored under ambient and ZECC conditions.

Treatments	Storage cond.	TSS (°Brix)					
		Day 0	Day 3	Day 6	Day 9	Mean	Mean of treatments
T_0 (Control)	AT	11.86 a	12.58 a	15.75 a	19.98 a	15.04 a	14.11 a
	ZECC	11.99 a	12.25 ab	13.43 cd	15.02 c	13.17 bcd	
T_1 (1% $CaCl_2$)	AT	12.01 a	12.47 ab	14.52 b	19.11 a	14.53 a	13.72 ab
	ZECC	11.98 a	12.09 ab	13.12 de	14.46 cd	12.91 cde	
T_2 (2% $CaCl_2$)	AT	12.13 a	12.37 ab	13.68 cd	17.29 b	13.87 abc	12.95 ab
	ZECC	11.70 a	12.00 ab	12.12 f	12.31 e	12.03 e	
T_3 (10% *Aloe vera* gel)	AT	11.85 a	12.37 ab	14.10 bc	17.87 b	14.05 ab	13.30 ab
	ZECC	11.69 a	11.88 ab	12.66 ef	13.97 d	12.55 de	
T_4 (15% *Aloe vera* gel +	AT	12.14 a	12.28 ab	13.61 cd	15.41 c	13.36 bcd	12.63 b
1.5% Ascorbic acid)	ZECC	11.69 a	11.76 b	11.95 f	12.15 e	11.89 e	
Means of storage days		11.90 c	12.21 c	13.49 b	15.76 a	-	-
Mean of storage conditions				AT		14.17 a	
				ZECC		12.51 b	

AT = ambient temperature, ZECC = zero energy cool chamber.

maximum juice TSS was recorded in untreated fruits (T_0) kept at room temperature and the minimum in the fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) stored in the cool chamber. At day 6 and 9, the maximum TSS was also observed in uncoated fruits (T_0) shelfed at room temperature and the minimum in those coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 2% $CaCl_2$ (T_2) kept in the cool chamber (Table 2).

Juice pH

Overall, the maximum juice pH was observed in T_0 (control) and T_1 ($CaCl_2$ 1%), followed by in T_3 (10% *Aloe vera* gel), whereas the minimum juice pH values were observed in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid) and T_2 ($CaCl_2$ 2%), followed by T_3 (10% *Aloe vera* gel). The former three treatments behaved statistically alike and latter three treatments also stood statistically at par with each other as demonstrated in Table 3. Regarding the storage of fruits, juice pH increased with the passage of time. Juice pH was the minimum on day 0 and the maximum on day 9. Moreover, when the fruits were stored at ambient conditions, these had significantly higher juice pH than those kept in the cool chamber.

Concerning the interactive effect of coating treatments and storage conditions, uncoated fruits (T_0) and those treated with 1% $CaCl_2$ (T1) and 10% *Aloe vera* gel (T_3) shelfed at ambient temperature resulted in higher juice pH values than all other treatment combinations. Regarding the cumulative effect of all the three factors (coating treatments, storage conditions and storage periods); at day 3, the maximum pH was recorded in T_0 (control) which was at par with T_1 ($CaCl_2$ 1%) and T_3 (10% *Aloe vera* gel) when kept at room temperature. The minimum pH was observed in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid) when fruits were stored in the cool chamber, which was followed by the same treatments when fruits were kept at ambient temperature and all other coating treatments when fruits were stored in the cool chamber. At day 6 and 9, significantly greater juice pH values were estimated in T_0 (Control) and T_1 (1% $CaCl_2$) when fruits were shelfed at ambient temperature. However, at day 6, the minimum pH was observed in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid) cool chamber stored fruits, which was followed by all other coating treatments when fruits were stored in the cool chamber and in T_4 when fruits were kept at ambient temperature. At day 9, the fruit juices had more acidic value in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid) when fruits were stored in the cool chamber, followed by T_2 ($CaCl_2$ 2%), T_1 ($CaCl_2$ 1%) and T_3 (10% *Aloe vera* gel) when stored in the cool chamber

Table 3: Changes in juice pH of guava fruits treated with coating materials and stored under ambient and ZECC conditions.

Treatments	Storage cond.	Juice pH					
		Day 0	Day 3	Day 6	Day 9	Mean	Mean of treatments
T_0 (Control)	AT	4.55 a	5.84 a	5.93 a	5.99 a	5.58 a	5.22 a
	ZECC	4.51 a	4.86 bc	4.98 c	5.10 c	4.86 b	
T_1 (1% $CaCl_2$)	AT	4.68 a	5.83 a	5.93 a	5.95 a	5.60 a	5.25 a
	ZECC	4.77 a	4.86 bc	4.92 c	5.01 cd	4.89 b	
T_2 (2% $CaCl_2$)	AT	4.54 a	4.94 b	5.01 c	5.11 c	4.90 b	4.85 b
	ZECC	4.65 a	4.78 bc	4.83 c	4.94 cd	4.80 b	
T_3 (10% *Aloe vera* gel)	AT	4.75 a	5.56 a	5.67 b	5.73 b	5.43 a	5.14 ab
	ZECC	4.61 a	4.84 bc	4.91 c	5.04 cd	4.85 b	
T_4 (15% *Aloe vera* gel +	AT	4.65 a	4.89 bc	5.00 c	5.09 cd	4.91 b	4.85 b
1.5% Ascorbic acid)	ZECC	4.72 a	4.74 c	4.82 c	4.87 d	4.79 b	
Means of storage days		4.64 c	5.11 b	5.20 ab	5.29 a	-	-
Mean of storage conditions				AT		5.28 a	
				ZECC		4.84 b	

AT = ambient temperature, ZECC = zero energy cool chamber.

Table 4: Changes in color of guava fruits treated with coating materials and stored under ambient and ZECC conditions.

Treatments	Storage cond.	Fruit color			
		Day 0	Day 3	Day 6	Day 9
T_0 (Control)	AT	Dark green	Yellow green	Brown	Dark brown
	ZECC	Dark green	Yellow green	Yellow	Brown
T_1 (1% $CaCl_2$)	AT	Dark green	Yellow green	Brown yellow	Dark brown
	ZECC	Dark green	Yellow green	Yellow	Yellow brown
T_2 (2% $CaCl_2$)	AT	Dark green	Yellow green	Brown yellow	Dark brown
	ZECC	Dark green	Yellow green	Yellow green	Yellow
T_3 (10% *Aloe vera* gel)	AT	Dark green	Yellow green	Brown yellow	Dark brown
	ZECC	Dark green	Yellow green	Yellow	Yellow brown
T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid)	AT	Dark green	Yellow green	Brown yellow	Dark brown
	ZECC	Dark green	Yellow green	Yellow green	Yellow
Means of storage days		Dark green	Yellow green	Yellow	Brown

AT = ambient temperature, ZECC = zero energy cool chamber.

and in T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid) when stored at room temperature (Table 3).

Fruit colour

Fruits were harvested at commercial maturity stage when they had dark green colour. In general, after 3 days of storage they became yellow green, after 6 days of storage their colour turned to yellow and after 9 days of storage these were brown in colour. As far as coating treatments and storage conditions are concerned, after 3 days of storage all the fruits were yellow green in all the coating treatments at both storage conditions. After 6 days of storage, fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 2% $CaCl_2$ (T_2) stored in the cool chamber were still yellow green, while uncoated fruits (T_0) kept at room temperature turned to brown colour. The fruit colour in other treatment combination was yellow to brown yellow. After 9 days of storage, all the fruits stored at room temperature became dark brown, irrespective of the coating treatments. Fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 2% $CaCl_2$ (T_2) stored in the cool chamber were yellow in colour, while fruits treated with 10% *Aloe vera* gel (T_3) and 1% $CaCl_2$ (T_1) stored in the cool chamber were brown yellow and uncoated fruits (T_0) kept in cool chamber turned to brown colour (Table 4).

Table 5: Economic shelf-life of guava fruits treated with coating materials and stored under ambient and ZECC conditions.

Treatments	Storage cond.	Shelf-life (days)	
		Mean	Mean of treatments
T_0 (Control)	AT	3.75 e	5.00 c
	ZECC	6.25 c	
T_1 (1% $CaCl_2$)	AT	4.75 d	6.50 b
	ZECC	8.25 b	
T_2 (2% $CaCl_2$)	AT	5.75 c	7.50 a
	ZECC	9.25 a	
T_3 (10% *Aloe vera* gel)	AT	4.50 d	6.62 b
	ZECC	8.75 ab	
T_4 (15% *Aloe vera* gel + 1.5% Ascorbic acid)	AT	6.00 c	7.62 a
	ZECC	9.25 a	
Mean of storage conditions		AT	4.95 b
		ZECC	8.35 a

AT = ambient temperature, ZECC = zero energy cool chamber.

Shelf life

Fruits treated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 2% $CaCl_2$ (T_2) had significantly longer shelf life of 7.62 and 7.5 days, respectively. On the other hand, untreated (control, T_0) fruits resulted in significantly shorter postharvest life (5.0 days). Fruits treated with 10% *Aloe vera* gel (T_3) and $CaCl_2$ 1% (T_1) were in between with shelf life of 6.62 and 6.5 days, respectively. Fruits kept in the zero-energy cool chamber resulted in the extended shelf life (8.35 days) as compared to those shelfed at ambient temperature (4.95 days).

Regarding the interaction between coating treatments and storage conditions, uncoated fruits (T_0) kept at room temperature had the shortest shelf life (3.75 days). Fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid (T_4) and 2% $CaCl_2$ (T_2) stored in the cool chamber resulted in enhanced shelf life of 9.25 days followed by the fruits coated with 10% *Aloe vera* gel (T_3) also shelfed in the cool chamber (8.25 days), indicating supremacy of cool chamber storage (Table 5).

DISCUSSION

Weight loss is the measure of weight before and after an interval of time or storage period. Weight loss may occur due to transpiration or respiration activity (Zhu et al., 2008). Mostly weight loss occurs due to loss of water from fruit surfaces. Some other factors like temperature and humidity have a marked effect on weight loss and shelf life of fruits, so these are kept at low temperatures and high humidity conditions. All the treatments used in the present work showed good results in preventing the weight loss but *Aloe vera* gel treatments (15% *Aloe vera* gel + 1.5% Ascorbic acid, and 10% *Aloe vera* gel) showed the best results and had lower weight loss as compared to control and other coating treatments. These results are in accordance with the findings of Valverde et al. (2005), who recorded more weight loss in the uncoated (control) fruits as compared to *Aloe vera* gel-coated fruits. By using *Aloe vera* gel coatings, similar results of weight loss were observed in grapes (Ali et al., 2016). This might be possibly due to thin coated layer on fruits (as in case of *Aloe vera* gel), which decreased transpiration from the fruit surface, resulting in reduced weight loss. Similarly, packing with cling and shrink film is also effective in preventing weight loss. In terms of total soluble solids (°Brix) and juice pH values, experimental result showed that untreated fruits ripened rapidly, while 15% *Aloe vera* gel + 1.5% Ascorbic acid and 2% $CaCl_2$ treatments delayed ripening with lower TSS and juice pH values. *Aloe vera* gel reduces transpiration and respiration from fruits resulting in delayed ripening. Ascorbic acid is an antioxidant which also retards aging (ripening and senescence) process. Calcium chloride ($CaCl_2$) as chemical coating delays fruit ripening which thus decreases starch to sugar conversion. As a result, the TSS of guava did not increase rapidly resulting in increased shelf life. These findings are in accordance with the results of Ozer et al. (2006). Role of $CaCl_2$ in delaying fruit ripening has also been reported in mango (Anjum and Ali, 2004). However, in the present experiment 1% concentration of $CaCl_2$ was low and not much effective, while 2% was effective in delaying the ripening process. Thus 2% $CaCl_2$ treatment also resulted in lower TSS with acidic fruits.

There are several factors which affect ripening of fruits these include various pre-harvest and postharvest factors. Maturity stage at harvesting also affects the fruit ripening process. Among the postharvest factors, handling, and storage conditions (temperature, humidity, gaseous composition etc.) markedly influence ripening and shelf life of fruits. Low temperature delays the ripening and senescence processes by lowering rates of transpiration, respiration and ethylene production as well as different biochemical and compositional changes in the fruits, Thus, in the present study, the fruits kept at ambient temperature had significantly higher weight loss, greater TSS and pH values and short postharvest life indicating that zero energy cool chamber is a good option to store and enhance availability of guava fruits up to about 4 - 5 more days.

Guava is a climacteric fruit, highly perishable in nature with a short postharvest life. After harvesting, fruit ripens rapidly due to ethylene production. During ripening many physiological and biochemical changes occur in the fruits these include change in skin colour, softening of texture, conversion of carbohydrates into sugars etc. resulting in higher TSS and sugar contents. Thus, as the storage period is increased, fruit ripens and then leads to senescence. The increase in TSS is mainly because of conversion of starch and polysaccharides into sugars (Bourtoom, 2008). Fruit colour changes from dark green to yellow green, yellow, brown-yellow, brown, and dark brown depending upon the cultivars and pre-harvest and postharvest condition. Similar results were obtained in the present study. Normally, the shelf life of guava is 2 - 4 days when stored at ambient temperature depending upon the season but by applying different chemicals and edible coating materials and keeping at low temperature, it can be increased up to 9-10 days.

CONCLUSION

The guava fruits treated with different coating materials and kept in zero energy cool chamber exhibited better results as compared to untreated (control) fruits kept at ambient conditions. Cool chamber storage conditions were effective in increasing the shelf life of guava fruits. It is concluded that fruits coated with 15% *Aloe vera* gel + 1.5% Ascorbic acid and 2% $CaCl_2$ and kept in cool chamber were better as compared to the control and other treatments for increased shelf life of guava fruits which was about 9-10 days with lower weight loss and total soluble solids and juice pH value.

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