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A comparative study of different edible coatings on physico-chemical properties of guava (*Psidium guajava* L.) cv. Khaza during storage

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Abstract
Guava cv. Khaza is known to have a poor shelf life under ambient storage conditions. But application of post-harvest treatments like *Aloe vera* gel, Salicylic acid and Benzyladenine as post-harvest treatment can enhance shelf life of the fruits. Hence an attempt had been made to judge the efficacy of the treatments on shelf life and fruit qualities. *Aloe vera* gel can be used successfully to reduce physiological loss in weight of guava fruits upto 8th day. Benzyl adenine was also successful in retaining ascorbic acid in fruits of guava fruits upto 8th day. The control samples show high Physiological loss in weight. TSS (OB) showed a decrease with storage. The decline in titratable acidity was lesser in T_1 (*Aloe vera* gel). Ascorbic acid content fall drastically with storage but lesser decline was observed in *Aloe vera* gel treated fruits. Thus in general it can be concluded that *Aloe vera* gel (T_1) coating can be considered as the best treatment as it retained high ascorbic acid, titratable acidity, firmness and low PLW during the storage period. Followed by Salicylic acid (T_2) and Benzyl adenine (T_3).

Keywords: *Aloe vera*, salicylic acid, benzyl adenine, guava, storage

Introduction
Guava (*Psidium guajava* L.) also known as apple of the tropics being a climacteric fruit ripens rapidly and is highly perishable, a shelf-life period ranges from 3-4 days at room temperatures. So, it makes transportation and storage difficult (Bassetto *et al*., 2005) [7]. Moreover, during storage fruit ripening is characterized by green color loss, rot development, fruit softening, wilting, loss of brightness and undesirable biochemical changes (Jacomino *et al*., 2001) [12]. Retailing of guava fruit in India is usually carried out without refrigeration and therefore, the preservation of fruit at room temperature is highly desirable to reduce post harvest loss and improve its commercialization. The post harvest loss of guava in India is about 25-30% i.e. 4.5 lakh tonnes, worth rupees 180 crores (Patel *et al*., 2014) [21]. The post harvest losses can be minimized by checking the rate of transpiration and respiration, microbial infection and protecting membranes from disorganization (Bisen and Pandey, 2008). Post harvest dipping treatment increases the shelf life of fruits by retaining their firmness and control of the decaying organism (Ahmed *et al*., 2009) [3].
Recently, interest has increased in using *Aloe vera* gel-based edible coating material for fruits and vegetables. This gel is tasteless, colorless and odourless. *Aloe vera* gel has been proven one of the best edible and biologically safe preservative coatings for different types of foods because of its film-forming properties, antimicrobial actions, biodegradability and biochemical properties. It is composed mainly of polysaccharides and acts as a natural barrier to moisture and oxygen, which are the main agents of deterioration of fruits and vegetables (Misir *et al*., 2014) [17]. *Aloe vera* gel coatings have a various favorable effect on fruits such as imparting a glossy appearance and better color, retarding weight loss, or prolonging storage/shelf-life by preventing microbial spoilage (Dang *et al*., 2008) [10] and has found to be effective in fruits such as table grapes (Castillo *et al*., 2010) [9], sweet cherries (Martinez *et al.,* 2006) and nectarines (Ahmed *et al*., 2009) [3]. *Aloe vera* gel has not been tried in guava earlier.
Salicylic acid, which belongs to a group of phenolic compounds, is widely distributed in plants and it is now considered as a hormonal substance, playing an important role in regulating a large variety of physiological processes. Salicylic acid influenced physiological or biochemical processes including ion uptake, membrane permeability, enzymes activity, heat production, growth and development (Arberg, 1981) [6]. Thus, salicylic acid has remarkable ability to maintain the quality during storage of fruits. Exogenous application of salicylic acid has been determined to delay ripening in a number of fruits by reducing the activities of major cell wall degrading enzymes *viz;* cellulase, polygalacturonase and xylanase (Srivastava and Dwivedi, 2000) [24] and by suppressing ACC synthase and ACC oxidase (Zhang *et al.,* 2003) [29].

The senescence delaying ability of cytokinins particularly 6-Benzyladenine (BA) has been explored in guava (Jayachandran *et al*., 2007 and Kumar *et al*., 2015) [13, 14] lettuce, Brussels sprouts, broccoli and celery (Van Staden and Joughin, 1990) [26]. Recently it has been reported that BA acts as antioxidant and has free radical quenching property which inhibited ethylene biosynthesis resulting in retardation of senescence and in many cases effectively reduced weight loss and increased storage period (Apelbaum, 1981 and Jayachandran *et al*., 2007) [5, 13].

Materials and Methods

The present study was carried out in the laboratory of Department of Post Harvest Technology of Horticultural Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, during the period from January 2018 to February 2018. Guava fruits were harvested at green mature stage and fruits free from mechanical damage and blemishes were sorted out. The fruits were then washed with distilled water to remove the dirt and other foreign matters. The fruits of specific gravity >1 were selected for experiment. After washing, the excess moisture was drained out from the fruits and then dried lightly at room temperature.

Experimental Details

Guava fruits after preparation were subjected to different treatment combination of growth substances (SA and BA) and *Aloe vera* gel for 5 minutes. Each treatment was replicated four time and the experiment was laid out in Factorial Completely Randomized Design. The treated fruits were stored in cool, dry place on racks at room temperature. The maximum and minimum temperature during the period at ambient condition varied from 24 ^{0}C and 18 ^{0}C respectively and relative humidity from 57 to 84% during the period of storage. Penetrometer (Model no. FT-327) was used to determine the firmness of the representative sample by puncturing at three different places of fruit (upper, middle and lower portion). Average firmness was expressed as kg/cm^2. Total soluble solid contents was estimated with a hand refractometer (Erma, Japan) and expressed as ^{0}Brix. Titratable acidity was determined as percentage citric acid according to method described in (AOAC, 1990) [4]. Ascorbic acid content of guava pulp samples were determined by 2, 6-dichlorophenol indophenol titration method as described by (Ranganna, 2000) [22].

Preparation and application of *Aloe vera* gel coating

After separating *Aloe vera* gel from the outer cortex, the hydroparenchyma was blended. This mixture was then filtered and the fibres were removed. The liquid obtained constituted fresh *Aloe vera* gel. Guava fruits were dipped in *Aloe vera* gel: distil water in 1:3 ratio (v:v) for 5 minutes where the specific gravity of *Aloe vera* gel used was 1.02.

6-Benzyladenine (BA)

A stock solution of 50ppm Benzyadenine (BA) was prepared by dissolving 50mg of BA in small quantity of 0.1N NaoH and the volume was made up with distilled water to 1litre. The fruits were then dipped in the solution of BA for 5 minutes and taken out and air dried.

Salicylic Acid (SA)

200ppm salicylic acid was prepared by dissolving 200mg of SA in a small quantity of acetone and then the volume was made up to 1000ml with distilled water. The guava fruits were dipped in the stock solution of SA for 5 minutes and then taken out and air dried.

Treatment Details

Treatment:

1. *Aloe vera* gel (AVg): distil water in 1:3 ratio (v:v) = T_1
2. Salicylic acid (SA) 200ppm = T_2
3. Benzyladenine (BA) 50ppm = T_3
4. Control = T_4

Results and Discussion

Physiological loss of weight (PLW%) of different treatments during storage of guava fruits is presented in Table 1. PLW% was significantly different for treatments, duration of storage as well as treatments × storage interaction at 5% level. Mean PLW% of treatments during the storage period upto 8 days was highest (4.920%) in control (T_4) and least (1.342%) in *Aloe vera* gel treated fruits (T_1). Irrespective of all treatments, mean physiological loss in weight increased significantly with the enhancement of storage duration from (2.957%) 4days to (3.446%) 8days.

Fruit firmness exhibited significant difference between treatments and treatments × storage interactions however storage duration was non- significant at 5% level (Table 1). Mean firmness of treated fruits on different days of storage decreased with advancement of storage period from 3.117 kg/cm^2 on 4th day to 3.006 kg/cm^2 on 8th day of storage. Firmness decreased steadily in T_2 (Salicylic acid) and T_4 (control). Irrespective of storage, average firmness of different treatments was recorded to be maximum (3.705 kg/cm^2) in T_1 (*Aloe vera* gel), 3.200 kg/cm^2 in T_2 (Salicylic acid), 3.007 kg/cm^2 in T_3 (Benzyl adenine) in decreasing order and lowest (2.333kg/cm^2) in T_4 (control). On 8th day of storage, firmness of T_1 (*Aloe vera* gel) treated fruits remained significantly higher than other treatments. Firmness of control fruits decreased abrubtly and became as low as 1.667 kg/cm^2 on the 8th day of storage.

Acidity of guava as affected by different post harvest treatments during storage is shown in Table 1. Acidity had a significant effect for treatment and storage duration but non-significant for treatment × storage interaction at 5% level. Initial acidity on the day of post harvest treatment ('0' days of storage) was recorded to be 0.404%. Acidity decreased on 4th day in all the treatments except in T_1 (*Aloe vera* gel) where it increased upto 0.603% but then it gradually decreased further during the subsequent period of storage. Acidity on 8th day of storage was highest 0.437% in T_1 (*Aloe vera* gel), 0.348% T_3 (Benzyl adenine), 0.303% T_2 (Salicylic acid) and 0.231% in T_4 (control) in decreasing order. Irrespective of treatments, mean acidity of different days of storage decreased from 0.410% on 4th day to 0.330% on the 8th day. Throughout the storage period T_1 retained higher acidity compared to other treatments and on 8th day maximum acidity was retained by T_1, T_3 followed by T_2.

Total soluble solids (TSS) as affected by different post harvest treatments during storage are shown in Table 2. TSS was significantly influenced by treatment, storage duration, however it was found to be non-significant for treatment × storage interaction at 5% level. Initial TSS of fruits at '0' days of storage was 7.51^{O}Brix. In all the treatments TSS was found to decrease gradually on the 4th day of storage however on the 8th day of storage the TSS slightly increased. This may be due to over ripening of fruits. The mean was found to be highest 7.067 ^{O}Brix in T_4 followed by T_2 (7.000 ^{O}Brix), T_3 (6.383 ^{O}Brix) and T_1 (5.88 ^{O}Brix) in decreasing order. The mean TSS

during storage from 4th day to 8th day day of storage increased from 6.167 OBrix to 7 OBrix respectively.

Ascorbic acid changes in the fruits as influenced by treatments and storage duration has been presented in Table 2. Ascorbic acid exhibited significant effects for treatment, storage duration and treatment × storage interaction at 5% level. Initial ascorbic acid content of untreated guava fruits was 297.11 mg/100gm. Ascorbic acid continuously decreased in all the treatments during storage. Mean ascorbic acid content during storage was observed to be maximum (233.013 mg/100gm) in T_1 followed by 233.770 mg/100gm in T3, 180.72 mg/100gm in T_2 and lastly 173.143 mg/100gm in T_4 in decreasing order. There was no significant difference between the mean treatments of T_1 and T_2. Irrespective of treatments, mean ascorbic acid content during storage decreased significantly from 4th day of storage (260.283 mg/100gm) to 8th day of storage (145.046 mg/100gm). Throughout the storage period T_1 maintained the highest ascorbic acid on 8th day of storage followed by T_3, T_2 then T_4. Control fruits possessed least ascorbic acid content 88.133 mg/100gm on the 8th day of storage.

The results indicated that post harvest treatment of fruits with *Aloe vera* gel i.e., T1 exhibited least PLW and TSS but retained higher firmness, acidity and ascorbic acid as compared to other treatments. This was followed by T3 (Benzyl adenine) which had no significant difference with T1 (Avg) in terms of ascorbic acid content. However, T4 (control) showed high physiological weight loss as well as least firmness, acidity and the lowest ascorbic content. The Total soluble solids content was highest in T4 as compared to other treatments. This may be due to over ripening of fruits without the protection of edible coatings. Coating manipulates levels of oxygen and carbon-dioxide within fruits and creates modified atmospheres rich in CO2, which is known to delay ripening (Smith *et al.,* 1987). Low PLW in *Aloe vera* gel treatments is caused by reduction of moisture loss which may be due to the hygroscopic properties of *Aloe vera* gel that allow the formation of water barrier between the fruit and the surrounding environment. Thus, preventing its external transferences (Morillon *et al.,* 2002) [18]. Interestingly, *Aloe vera* gel mostly composed of polysaccharide (Ni *et al*., 2004) [19] which is highly effective as a barrier against moisture loss without incorporation of lipid. *Aloe vera* gel has been proved to maintain the texture ie., firmness of fruit efficiently. This may be due to the effect of *A. vera* gel on the reduction of *â*-galactosidase, polygalacturonase, and pectin methyl-esterase activities (Nunan *et al*., 1998) [20]. Benzyl adenine has been reported to possess free radical quenching property which inhibited ethylene biosynthesis resulting in retardation of senescence and gradual build up of sugars (as in mango) (Ahmed, 1998) [3]. Softening in fruits is caused either by a breakdown of insoluble pectin or by hydrolysis of starch (Matto *et al*., 1975) [16]. BA has a retarding effect on decreasing the pectin content thereby delaying ripening and softening of guava fruits (Jayachandran *et al*., 2007) [13]. Salicylic acid plays a good role in post-harvest decay and disease resistance (Aghdam *et al*., 2009) [1], increase the plant defense against oxidative stress (Xu and Tian, 2008) [28], delaying fruit ripening (Srivastava and Dwivedi, 2000) [24]. The increase in TSS during storage may possibly be due to hydrolysis of starch into sugars as on complete hydrolysis of starch no further increase occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al*., 1981). Decline in titratable acidity during storage may be due to the metabolic changes in fruits resulting from the use of organic acids in the respiratory process (Echeverria and Valich, 1989) [11]. Another reason for decrease in titratable acidity during ripening and storage may be attributed to an increase in malic enzyme and pyruvate decarboxylation reaction during climacteric period (Rhodes *et al.,* 1968) [23].

Table 1: Effect of different treatments on the PLW (%), Firmness (kg/cm^2) and Acidity (%) of guava during storage

Treat-ments	PLW (%)			Firmness Kg/cm^2			Acidity (%)		
	Storage Days			Storage Days			Storage Days		
	4th	8th	Mean	4th	8th	Mean	4th	8th	Mean
T_1	1.350	1.333	1.342	3.467	3.943	3.705	0.603	0.437	0.520
T_2	1.933	2.533	2.233	3.267	3.133	3.200	0.370	0.303	0.337
T_3	4.250	4.370	4.310	2.733	3.280	3.007	0.296	0.348	0.322
T_4	4.293	5.547	4.920	3.000	1.667	2.333	0.370	0.231	0.300
Mean	2.957	3.446		3.117	3.006		0.410	0.330	
	T	S	T×S	T	S	T×S	T	S	T×S
S.Em ±	0.101	0.072	0.143	0.125	0.088	0.177	0.031	0.022	0.043
C.D at 5%	0.306	0.217	0.433	0.378	NS	0.535	0.093	0.065	NS

T_1 = *Aloe vera* gel (AVg), T_2 = Salicylic acid (SA), T_3 = Benzyl adenine (BA), T_4 = Control (C), NS= Non significant, T= Treatment, S= Storage

Initial Acidity (fresh sample) = 0.404%

Table 2: Effect of different treatments on the TSS (OBrix) and Ascorbic acid (mg/100gm) of guava during storage

Treat-ments	TSS (O Brix)			Ascorbic acid (mg/100gm)		
	Storage Days			Storage Days		
	4th	8th	Mean	4th	8th	Mean
T_1	5.333	6.433	5.883	263.747	202.280	233.013
T_2	6.667	7.333	7.000	258.153	103.310	180.732
T_3	6.000	6.767	6.383	261.080	186.460	223.770
T_4	6.667	7.467	7.067	258.153	88.133	173.143
Mean	6.167	7.000		260.283	145.046	
	T	S	T×S	T	S	T×S
S.Em ±	0.192	0.136	0.272	7.189	5.083	10.167
C.D at 5%	0.581	0.411	NS	21.739	15.371	30.742

T_1 = *Aloe vera* gel (AVg), T_2 = Salicylic acid (SA), T_3 = Benzyl adenine (BA), T_4 = Control (C), NS= Non significant, T= Treatment, S= Storage

Initial TSS (fresh sample) = 7.51

Initial ascorbic acid (fresh sample) = 297.11 mg/100gm

Conclusion

Thus in general it can be concluded that *Aloe vera* gel (T_1) coating can be considered as the best treatment as it retained high ascorbic acid, titratable acidity, firmness and low PLW during the storage period. Followed by Salicylic acid (T_2) and Benzyl adenine (T_3).

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