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Effect of Different Post-Harvest Treatments and Prepackaging on Storage Behavior of Guava (*Psidium guajava*) cv. Khaza

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A B S T R A C T

Guava cv. Khaza is known to have a poor shelf life under ambient storage conditions. But application of post-harvest treatments like *Aloevera* gel, Salicylic acid and Benzyladenine as post-harvest treatment followed by pre-packaging in polyethylene film of different thickness can enhance shelf life of the fruits. Hence an attempt had been made to judge the efficacy of the treatments with their interaction with packaging practices on shelf life and fruit qualities. Aloevera x 50μ LDPE can be used successfully to reduce physiological loss in weight of guava fruits upto 9^{th} day. Benzyl adenine x 50μ LDPE was successful in retaining fruit firmness of guava fruits upto 9^{th} day. Most of the interactions were able to ensure fruit colour (light yellow) upto 9^{th} days of storage. The control samples only show change in colour to yellow irrespective of the packaging used. TSS (^{O}B) showed a decrease with storage. But the rate of decline was lesser in case of Benzyl adenine x 50μ LDPE (6.9 ^{O}B) followed by *Aloevera* gel x 50μ LDPE (6.83 ^{O}B). The decline in titratable acidity was lesser in Salicylic acid x 25μ LDPE (0.363). Ascorbic acid content fall drastically with storage but lesser decline was observed in Aloevera x 50μ LDPE (133.01), Aloevera gel x 25μ LDPE (126.59), Benzyl adenine x 25μ LDPE (126.58) and Salicylic acid x Aloevera gel (118.33). Hedonic scores based on organoleptic properties were maximum in T_3P_1 (5.87) followed by T_1P_1 (5.73) at 9^{th} day of storage.

Introduction

Guava (*Psidium guajava L.*) is also known as the apple of the tropics. It is one of the most popular fruit grown in the tropical, sub-tropical and some parts of arid regions of India. Guava is one of the most important fruit crop. India is the leading producer of guava in the world. At present, it ranks fifth among the fruits grown in India occupying 2.55 lakh hectare area with annual production of 4.1 million tonnes (Anonymous, 2015). The fruit is a rich source of Vitamin C and pectin. It is also a good source of calcium, phosphorous, pentothenic acid, riboflavin, thiamine, niacin and vitamin A (Paul and Goo, 1983).

Guava 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). 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). 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 rupees180 crores (Patel *et al.*, 2014). 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).

Recently, interest has increased in using *Aloevera* gel-based edible coating material for fruits and vegetables. This gel is tasteless, colorless and odourless. *Aloevera* 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 and bio-degradability 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). *Aloevera* 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) and has found to be effective in fruits such as table grapes (Castillo *et al.*, 2010), sweet cherries (Martinez *et al.*, 2006) and nectarines (Ahmed *et al.*, 2009). *Aloevera* gel has not been tried in guava earlier. *Mani et al.*, (2017) have found that aloevera gel when used in ber cv. Umran can successfully enhance its shelf life of upto 15th day of ambient storage.

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).

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) and by suppressing ACC synthase and ACC oxidase (Zhang *et al.*, 2003).

The senescence delaying ability of cytokinins particularly 6-Benzyladenine (BA) has been explored in guava (Jayachandran *et al.*, 2007 and Kumar *et al.*, 2015) lettuce, Brussels sprouts, broccoli and celery (Van Staden and Joughin, 1990). 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).

Previous reports indicated the prospect of maintaining quality and increasing shelf-life of guava by packaging with polyethylene film (LDPE) (Kore and Kabir, 2011 and Kaur *et al.*, 2014). Therefore, an attempt has been made to prolong the shelf life of guava fruits using *Aloevera* gel, Salicylic acid and

Benzyladenine as post-harvest treatment followed by pre-packaging in polyethylene film of different thickness. The polyethylene packaging further might have concomitant effect in delaying senescence and physiological processes by creating modified atmospheric condition around the produce by controlling the gaseous (CO_2 and O_2) concentration in the package (Neeraj *et al.*, 2003). Considering all the above facts an attempt has been made to study the combine effect of post-harvest treatments and pre-packaging on physico-chemical changes during ripening of guava fruits.

Materials and Methods

Experimental site

Laboratory of Department of Post-Harvest Technology of Horticultural Crops, faculty of Horticulture, BCKV, Mohanpur, Nadia during the period from February 2017 to March 2017.

Source of material

Well-developed mature fruits of guava cv. Khaza were harvested at green mature stage in the morning from the well maintained orchard at Ghoragacha village near Mohanpur and immediately brought to the laboratory of Department of Post-Harvest Technology of Horticultural Crops.

Application of Treatments

Application of *Aloevera* gel coating

After separating *Aloevera* gel from the outer cortex, this colourless hydroparenchyma was blended. This mixture was filtered to remove fibres. The liquid obtained constituted fresh *Aloevera* gel. Guava fruits were dipped in *Aloevera* gel: distil water in 1:3 ratio (v:v) for 5 minutes where the specific gravity of *Aloevera* 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 to one litre with distilled water. The fruits were then dipped in the solution of BA for 5 minutes and then taken out and air dried.

Salicylic acid

A stock solution of 200ppm salicylic acid was prepared by dissolving 200mg of SA in a small quantity of acetone first and then the volume was made up to 1000ml or one litre with distilled water.

The guava fruits were then dipped in the stock solution of SA for 5 minutes and then taken out and air dried.

Packaging of treated fruits

Low density polyethylene bags of 25µ and 50µ thickness and 45 × 30 cm size with 1% perforation were used for the experiment. The size of each perforation was approximately $0.125cm^2$.

Experimental details

Guava fruits after preparation were subjected to different treatment combination of growth substances (SA and BA) and *Aloevera* gel for 5 minutes. Each treatment was replicated four times.

Treatment details

The treatments are actually the varied combinations of different treatments and the packaging materials employed. The different combinations are T_1P_1 = Aloevera gel: water (1:3) with LDPE 25µ; T_1P_2 = Aloevera gel: water (1:3) with LDPE 50µ; T_2P_1 = Salicylic acid 200ppm with LDPE 25µ; T_2P_2 = Salicylic acid 200ppm with LDPE 50µ; T_3P_1 = 6-Benzyl Adenine (50ppm) with LDPE 25µ; T_3P_2 = 6-Benzyl Adenine (50ppm) with LDPE 50µ; T_4P_1 = Control + LDPE 25µ and T_4P_2 = Control + LDPE 50µ.

Design of experiment

Two Factor Factorial Completely Randomized design was adopted where Factor 1 is the number of treatments (4) and Factor 2 is the thickness of LDPE (2). Hence the total numbers of treatment combinations were 8, with 4 replications each. The total number of fruits taken per replications was 8. SPSS 21 software was used to analyze the data statistically.

Parameters analyzed

Different parameters were analyzed for their physical, bio-chemical and organoleptic properties on 3^{rd}, 5^{th} and 9^{th} day of storage.

Physical properties of fruits

Physiological loss in weight (PLW %)

For determining the physiological loss in weight, fruits were numbered and weighed individually on the day of observation. It was expressed as percentage of the original fresh weights of the fruit.

$$\text{PLW (\%)} = \frac{\text{Initial fruit weight} - \text{final weight of the fruit}}{\text{Initial fruit weight}} \times 100$$

Fruit firmness

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.

Biochemical properties

Total soluble solids (^{0}Brix)

TSS value of the fruit was determined by hand refractometer.

Acidity (%)

The acidity and ascorbic acid were estimated by the method described by Rangana.

Ascorbic acid (mg/100g)

The acidity and ascorbic acid were estimated by the method described by Rangana.

Organoleptic evaluation of fruits

Organoleptic evaluation was recorded of physical characters of fruits *viz.*, fruit appearance (colour), taste, firmness and flavour by a panel of judges as per “hedonic scale” 1-9 point according to Rajkumar *et al.*, (2006).

Results and Discussion

Table 1 shows the interaction between treatments and polyethylene thickness on PLW revealed non-significant effect on 3^{rd} and 6^{th} day and significant effect on 9^{th} day of storage. Low PLW was observed in the interaction treatment of T_1P_2 (*Aloevera* gel × 50µ LDPE) and T_2P_2 (Salicylic acid × 50µ LDPE) on 3^{rd} day (0.67% and 0.88% respectively) and 6^{th} day (1.67 % and 1.62% respectively). On 9^{th} day PLW was significantly low (3.22%) in T_1P_2 (*Aloevera gel* × 50µ LDPE), followed by 3.83% in T_3P_2 (Benzyladenine × 50µ LDPE), 3.97% in T_2P_1 (Salicylic acid × 25µ LDPE), 4.20% in T_1P_1 (*Aloevera* gel × 25µ LDPE) and so on in that increasing order. T_4P_1 (Control × 25µ LDPE) exhibited highest PLW of 5.60% on 9^{th} day. PLW of T_1P_2 (*Aloevera* gel × 50µ LDPE) and

T_3P_2 (Benzyladenine × 50µ LDPE) was not significantly different and the two interaction treatments were at par.

Table 2 depicts the combined effect of treatments × LDPE thickness indicated significant effect on the 3rd and 6th day of storage and non- significant on 9th day of storage (Table 5). On 3rd day firmness of combination T_2P_1 (Salicylic acid × 25µ LDPE) was observed to be maximum (3.47 kg/cm^2). This was followed by T_1P_2 (*Aloevera* gel × 50µ LDPE), T_1P_1 (*Aloevera* gel × 25µ LDPE), T_4P_1 (control × 25µ LDPE) and so on in decreasing order. However, there was no significant difference between these treatments and these treatment combinations were at par on the 3rd day of storage.

Firmness declined steadily in combined treatments of T_1P_1 (*Aloevera* gel × 25µ LDPE), T_1P_2 (*Aloevera* gel × 50 LDPE), T_3P_2 (Benzyladenine × 50µ LDPE) and retained higher firmness than T_4P_1 (control × 25µ LDPE) and T_4P_2 (control × 50µ LDPE) on the 6th and 9th day of storage. It was further observed that T_1P_1 (*Aloevera* gel × 25µ LDPE) possessed significantly higher firmness compared to all other treatment combinations on 6th day of storage and it also maintained higher firmness on the 9th day of storage. The firmness of T_4 (Control) reduced abruptly to 1.30kg/cm^2.

Table 3 shows the interaction effect of treatments and polyethylene thickness on visual colour change of the fruits. At 3rd day of storage the guava fruit colour was green in T1P1, T2P1, T2P2; light green in T1P2, T3P1, T3P2 and T4P2. At 6th day of storage, The fruit colour changed fro, light green to green in T1P1, T2P1 and T2P2; light yellow tinge was observed in fruits of T1P2 and T3P2; creamy light green in T3P1; light yellow in T4P1 and T4P2. At 9th days of storage T1P1, T1P2, T2P1, T2P2 and T3P3 were light yellow in colour whereas T3P1, T4P1 AND T4P2 showed yellow coloured fruits.

Table 4 shows the interaction effect of treatments and polyethylene thickness has been presented. The interaction effect was non- significant on the 9th day of storage while on 3rd and 6th day it was significant. On 3rd day the combined effect of T_1P_1 (*Aloevera* gel × 25µ LDPE) and T_2P_1 (Salicylic acid × 25µ LDPE) recorded maximum TSS of 9.26 ºBrix followed by 8.86 ºBrix in T_4P_1 (control × 25µ LDPE), 8.53 ºBrix in T_2P_2 (Salicylic acid × 50µ LDPE) 8.46 ºBrix in T_3P_1 (Benzyladenine × 25µ LDPE), 8.33 ºBrix in T_1P_2 (*Aloevera* gel × 50µ LDPE), etc, on that decreasing order. TSS of T_4P_1 reduced abruptly to 6.40 ºBrix on 6th day, followed by 6.23 ºBrix on 9th day. On 6th day the TSS of the combination T_1P_1 (8.06 ºBrix), T_2P_1 (8.33ºBrix), T_2P_2 (7.86 ºBrix) were significantly higher than the combination of control with thickness i.e., T_4P_1 (6.4 ºBrix) and T_4P_2 (7.06 ºBrix). Other interaction treatments for TSS on 6th day like T_1P_2, T_3P_2, T_3P_1 were significantly higher than the combination of control with lower thickness i.e., $T_4P_{1.}$

On 9th day although there was no significant difference between interaction treatment on TSS, however, T_3P_2 (Benzyladenine × 50µ LDPE) retained maximum TSS of 6.90 ºBrix followed by T_1P_2 (*Aloevera* gel × 50µ LDPE) of 6.83ºBrix, T_3P_1 (6.63 ºBrix), T_2P_1 (6.51 ºBrix), T_1P_1 (6.50 ºBrix) and so on in that decreasing order.

The interaction effect of treatment and thickness for titratable acidity is shown in Table 9. The interaction effect of titratable acidity was significant at 5% level on 3rd, 6th and 9th day of storage. It was observed that combined effect of T_3P_1 (Benzyladenine × 25µ LDPE) retained higher acidity during early period of storage i.e., 3rd day (0.389%) and 6th day (0.369%).

Table.1 Interaction effect of different treatments and polyethylene thickness on physiological loss in weight (%) of guava during storage

Treatments	Storage period (days)		
	PLW (%)		
	3rd day	6th day	9th day
T_1P_1	0.94	2.12	4.20
T_1P_2	0.67	1.67	3.22
T_2P1	1.34	1.88	3.97
T_2P_2	0.88	1.62	4.69
T_3P_1	1.02	2.63	4.53
T_3P_2	1.62	2.62	3.83
T_4P_1	1.42	2.75	5.60
T_4P_2	1.8	2.74	4.91
S. Em ±	**0.278**	**0.298**	**0.229**
C.D at 0.05	**N.S**	**N.S**	**0.694**

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25μ LDPE, P2 = 50μ LDPE

Table.2 Interaction effect of different treatments and polyethylene thickness on firmness of guava during storage

Treatments	Storage period (days)		
	Firmness (Kg/cm^2)		
	3rd day	6th day	9th day
T_1P_1	2.97	2.70	1.43
T_1P_2	3.03	1.83	1.33
T_2P1	3.47	1.70	1.42
T_2P_2	1.90	1.40	1.35
T_3P_1	2.27	1.33	1.20
T_3P_2	1.90	1.83	1.45
T_4P_1	2.80	1.70	1.40
T_4P_2	1.93	1.73	1.20
S. Em ±	**0.23**	**0.18**	**0.09**
C.D at 0.05	**0.69**	**0.54**	**N.S**

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25μ LDPE, P2 = 50μ LDPE

Table.3 Interaction effect of different treatments and polyethylene thickness on colour of guava during storage

Treatments	Storage period (days)		
	Colour (visual observation)		
	3rd day	6th day	9th day
T_1P_1	Green	Light green	Light yellow
T_1P_2	Light green	Light yellow tinge	Light yellow
T_2P1	Green	Light green	Light yellow
T_2P_2	Green	Light green	Light yellow
T_3P_1	Light green	Creamy light green	Yellow
T_3P_2	Light green	Light yellow tinge	Light yellow
T_4P_1	Creamy light green	Light yellow	Yellow
T_4P_2	Light green	Light yellow	Yellow

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25μ LDPE, P2 = 50μ LDPE

Table.4 Interaction effect of different treatments and polyethylene thickness on TSS (^{O}B) of guava during storage

Treatments	Storage period (days)		
	TSS (^{O}B)		
	3rd day	**6th day**	**9th day**
T_1P_1	9.26	8.06	6.50
T_1P_2	8.33	7.66	6.83
T_2P1	9.26	8.33	6.53
T_2P_2	8.53	7.86	6.26
T_3P_1	8.46	7.13	6.63
T_3P_2	7.93	7.53	6.90
T_4P_1	8.86	6.40	6.23
T_4P_2	7.93	7.06	5.93
S. Em ±	**0.194**	**0.217**	**0.275**
C.D at 0.05	**0.613**	**0.657**	**N.S**

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25µ LDPE, P2 = 50µ LDPE

Table.5 Interaction effect of different treatments and polyethylene thickness on titratable acidity of guava pulp during storage

Treatments	Storage period (days)		
	Titratable acidity (%)		
	3rd day	**6th day**	**9th day**
T_1P_1	0.341	0.327	0.289
T_1P_2	0.362	0.346	0.309
T_2P1	0.362	0.341	0.363
T_2P_2	0.336	0.245	0.242
T_3P_1	0.389	0.369	0.270
T_3P_2	0.288	0.277	0.229
T_4P_1	0.303	0.274	0.227
T_4P_2	0.325	0.304	0.209
S. Em ±	**0.021**	**0.014**	**0.020**
C.D at 0.05	**0.065**	**0.042**	**0.060**

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25µ LDPE, P2 = 50µ LDPE

Table.6 Interaction effect of different treatments and polyethylene thickness on ascorbic acid of guava during storage

Treatments	Storage period (days)	
	Ascorbic acid (mg/100g)	
	6th day	**9th day**
T_1P_1	162.98	126.59
T_1P_2	174.22	133.01
T_2P1	175.34	118.33
T_2P_2	174.21	99.98
T_3P_1	174.60	126.58
T_3P_2	139.37	86.68
T_4P_1	147.23	80.72
T_4P_2	139.37	76.13
S. Em ±	**5.53**	**9.409**
C.D at 0.05	**16.71**	**29.650**

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25µ LDPE, P2 = 50µ LDPE

Table.7 Interaction effect of different treatments and polyethylene thickness on organoleptic properties of guava during storage

Treatments	Storage period (days)		
	Taste perception		
	3rd day	6th day	9th day
T_1P_1	7.77	7.28	5.73
T_1P_2	7.77	7.03	5.27
T_2P1	7.85	6.83	5.43
T_2P_2	7.80	6.70	4.00
T_3P_1	7.68	6.95	5.87
T_3P_2	7.98	6.93	5.00
T_4P_1	7.50	6.38	4.00
T_4P_2	7.57	6.35	3.83
S. Em ±	**0.190**	**0.322**	**0.420**
C.D at 0.05	**N.S**	**N.S**	**N.S**

T1 = *Aloevera* gel, T2 = Salicylic acid, T3 = Benzyl adenine, T4 = Control, P1 = 25µ LDPE, P2 = 50µ LDPE

However, during later period of storage particularly on 9th day the combination of T_2P_1 (SA × 25µ LDPE), T_1P_2 (AVg × 50µ LDPE) and T_1P_1 (AVg × 25µ LDPE) maintained significantly higher acidity in the fruits i.e., 0.363%, 0.309% and 0.289% respectively compared to control combination i.e., T_4P_1 and T_4P_2 0.227% and 0.209% acidity respectively.

Table 6 shows the interaction effect between the treatment and thickness which revealed that T_2P_1 (Salicylic acid × 25µ LDPE) possessed significantly high (175.34 mg/100g) ascorbic acid than the control combination with thickness (T_4T_1 and T_4P_2) on the 5th day of storage. However, there is no significant difference with regard to ascorbic acid content on 5th day between treatment combinations T_1P_1, T_1P_2, T_2P_1, T_2P_2, T_3P_1 thus all these treatments were at par. On the 9th day maximum ascorbic acid (133.01mg/ 100g) was retained by T_1P_2 followed by T_1P_1 (126.59 mg/100g), T_3P_1 (126.58 mg/100g), T_2P_1 (118.33 mg/100g) and so on in that decreasing order. The control combination of T_4P_1 and T_4P_2 possessed less ascorbic acid of 80.72 mg/100g and 76.13 mg/100g respectively.

Interaction between treatments and polyethylene thickness is given in Table 7. The organoleptic score on 3rd, 6th and 9th day were non- significant. However, on the last day of storage (9th day) highest organoleptic score was retained by T_3P_1 (Benzyl adenine + 25µ LDPE) followed by T_1P_1 (*Aloevera* gel + 25µ LDPE), T_2P_2 (Salicylic acid + 50µ LDPE) and so on in that decreasing order.

By considering all the above tables it can be concluded that aloevera x 50µ LDPE can be used successfully to reduce physiological loss in weight of guava fruits upto 9th day. Benzyl adenine x 50µ LDPE was successful in retaining fruit firmness of guava fruits upto 9th day. However aloevera x 25 µ LDPE and Salicylic acid x 25 µ LDPE can also ensure good fruit firmness upto 9th days. Most of the interactions were able to ensure fruit colour (light yellow) upto 9th days of storage. The control samples only show change in colour to yellow irrespective of the packaging used. Hence there is a good effect of post-harvest treatment on ensuring reduction in chlorophyll degradation. TSS (^{O}B) showed a decrease with storage. But the rate of decline was lesser in case of Benzyl adenine x 50µ LDPE (6.9 ^{O}B) followed by *Aloevera* gel x 50µ LDPE (6.83 ^{O}B). There is a decline in titratable acidity of the fruits irrespective of the packaging practice and the post-harvest treatment subjected. However, the decline in titratable acidity was lesser in Salicylic acid x 25µ LDPE (0.363). Ascorbic acid content fell drastically with storage but lesser decline was observed in Aloevera x 50µ LDPE (133.01), Aloevera gel x 25µ LDPE (), Benzyl adenine x 25µ LDPE (126.58) and Salicylic acid x Aloevera gel (118.33). Hedonic scores based on organoleptic properties were maximum in T_3P_1 (5.87) followed by T_1P_1 (5.73) at 9th day of storage.

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