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Effect of organic based products as post-harvest treatments and storage studies on different varieties of sapota (*Manilkara zapota* (L.) P. Royen)

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Abstract
An experiment was conducted to investigate the effects of organic based products on postharvest quality and shelf life of different varieties of sapota. In this study, a factorial experiment base on randomize completely design was conducted with twenty one treatments and three replication. The first factor was dipping treatment of different varieties sapota fruits with organic based products such as chitosan (0.5%), chitosan (1.0%), carnauba wax (25%), carnauba wax (50%), *Aloe vera* gel: Distilled water (V/V) (1:1) and *Aloe vera* gel: Distilled water(V/V) (2:1) and second factor was varieties such as Kalipatti, Cricket ball and Pala. Post-harvest treated fruits were stored at ambient storage condition. Traits such as physiological loss in weight (PLW %), total soluble solids (TSS °B), fruit ripening percentage, fruit decay percentage and shelf life were measured. Results showed that application of *Aloe vera* gel at 1:1 ratio reduced PLW%, TSS°B, fruit ripening percent and fruit decay percentage whereas it increased shelf life. The highest PLW%, TSS°B, fruit ripening percent, fruit decay percentage and shelf life were observed in uncoated sapota fruits (control) in Pala variety. Therefore, application of postharvest *Aloe vera* gel in the ratio of 1:1 is recommended for improving quality and shelf life of sapota variety Cricket ball.

Keywords: Sapota**,** shelf life, carnauba wax and *Aloe vera* gel

Introduction
Sapota (*Manilkara zapota* (L.) P. Royen) is one of the prominent fruits in India and belongs to family Sapotaceae. It is one of the delicious fruit of humid tropical and sub-tropical regions. It is a native of Tropical America and has now spread to almost all tropical countries of the world. It is also called by other names such as chikku, sapota plum, sapodilla or prickly pear. Fully ripe fruit is delicious and eaten as dessert fruit. The pulp is sweet and melting. The usual practice is to eat only the pulp. The fruit skin can also be eaten since it is richer in nutrients than the pulp. The pulp is also made into sherbets and halvas. Sapota is used for the preparation of many indigenous medicines. Because of more tannin content in fruits, the decoction made by boiling of sapota fruits is used to stop diarrhea.

Carbohydrates and tannins are the main constituents of sapota and good source of digestible sugar, which ranges from 12 to 20 per cent. Free sugars are in high concentration in the mature fruit, while starch is almost absent. Fruit contains high concentrations of minerals such as potassium, calcium, iron, copper and zinc and phenolic components. The decrease in astringency during fruit development and ripening has been shown to be the result of polymeric changes, the interaction of other components such as sugars, and to a reduction in the concentration of polyphenols as fruit size increases (Lakshminarayana and Subramanyam, 1966 [9]). Several medicinal properties have been described to different parts of the sapota tree. Young fruits are rich in tannins used to cure diarrhea, Tea from old leaves is used to treat coughs, colds and diarrhea, crushed seeds are used as a diuretic, sedative, sopoforic and for kidney stones; the latex can be used to fill tooth cavities temporarily; and the bark can be used to make tea for treating fevers.

Sapota is highly perishable and shelf life of sapota fruit is very short (2–3 days) at ambient temperature. It is a climacteric fruit and main factor which trigger the ripening are the rate of ethylene production and respiration after harvest. Extension of shelf life of sapota fruit can be made possible by reducing the rate of respiration and ethylene evolution, which may be

achieved by proper post-harvest treatments like skin coating and treatment with chemicals. Various chemicals, bio agents and plant-based products have been used to delay ripening process, to reduce post-harvest losses to maintain the colour and quality by slowing down the metabolic activities of the fruit. These chemicals act as barrier for respiration, transpiration, arrest the growth and spread of micro-organism by reducing the shrivelling which ultimately leads to an increased shelf life and maintain the marketability of the fruit for a longer period. The storage behaviour of different varieties and hybrids of sapota under ambient storage conditions varies.

Materials and Methods

Materials and treatments

The present investigation was carried out at Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, India. The fruit of different sapota varieties *viz*., Kalipatti, Cricket Ball, Badami, Kirtibarathi, Guthi, Pala, Pakala, PKM-2, Gorayya and Singapore were harvested from Horticultural Research Station, Mallepally, Nalgonda district of Telangana at right maturity stage that is when skin colour of the fruits changed from light brown to dark brown (Potato like colour) and brown scale like structure on the surface of fruit was disappeared and brought to the laboratory in plastic crates. Further the fruits were washed in solution containing 0.2 per cent sodium hypochlorite for five minutes to remove the dirt and micro-flora present on the surface of the fruits. The sanitized fruits were surface dried under electric fan and those fruits were used for further experimentation. The fruits were treated with organic based products *viz*., Kalipatti + Chitosan (0.5%) (T1), Kalipatti + Chitosan (1%) (T2), Kalipatti + Carnauba wax (25%) (T3), Kalipatti + Carnauba wax (50%) (T4), Kalipatti + *Aloe vera* gel: Distilled water (V/V) (1:1) (T5), Kalipatti + *Aloe vera* gel: Distilled water (V/V) (2:1) (T6), Kalipatti + Control (T7), Cricket ball + Chitosan (0.5%) (T8), Cricket ball + Chitosan (1%) (T9), Cricket ball + Carnauba wax (25%) (T10), Cricket ball + Carnauba wax (50%) (T11), Cricket ball + *Aloe vera* gel: Distilled water (V/V) (1:1) (T12), Cricket ball + *Aloe vera* gel: Distilled water (V/V) (2:1) (T13), Cricket ball + Control (T14), Pala + Chitosan (0.5%) (T15), Pala + Chitosan (1%) (T16), Pala + Carnauba wax (25%) (T17), Pala + Carnauba wax (50%) (T18), Pala + *Aloe vera* gel: Distilled water (V/V) (1:1) (T19), Pala + *Aloe vera* gel: Distilled water (V/V) (2:1) (T20), Pala + Control (T20). After the imposition of post-harvest treatments (5 minutes), fruits were stored in ambient storage condition and then assessed for physical parameters and chemical parameters. The experimental data was analysed in factorial completely randomized block design with three replications.

Methodology for preparation of different post-harvest dipping solutions

Chitosan solution

Chitosan solution (0.5%) was prepared by dissolving 5 g of chitosan in 1000 ml of distilled water added with 2.5 ml glacial acetic acid. The mixture was heated with continuous stirring to facilitate proper dilution.

Wax solution

Carnauba wax formulation (25%) was prepared by diluting the 250 g carnauba wax flakes in 1000 ml of ethyl acetate and heated at 82-86 °C to dissolve properly.

Carnauba wax formulation (50%) was prepared by diluting the 500 g carnauba wax flakes in 1000 ml of ethyl acetate and heated at 82-86 °C to dissolve properly.

Aloe vera gel

The *Aloe vera* gel: Distilled water (V/V) (1:1) solution was prepared by dissolving commercial *Aloe vera* gel (1 litre) with 1 litre distilled water as a coating material.

The *Aloe vera* gel: Distilled water (V/V) (2:1) solution was prepared by dissolving commercial *Aloe vera* gel (2 litre) with 1 litre distilled water as a coating material.

Experimental design and data analysis

The data recorded on the physico-chemical and organoleptic parameters were subjected to statistical analysis in factorial completely randomized design. Randomly selected fruits were taken to analyse physiological loss in weight, Total Soluble Solids (TSS), ascorbic acid, titratable acidity, disease percentage and shelf life. Interpretation of the data was carried out in accordance with Panse and Sukhatme (1985) [17]. The level of significance used in 'F' test was p=0.05. Critical difference values were calculated wherever 'F' test was significant. Critical difference values were calculated whenever F-test was found significant.

Results and Discussion

Physiological loss in weight (%) (PLW)

The PLW of sapota fruits increased as the storage period progressed in all treatments. Among the 7 different post-harvest treatments, significantly minimum PLW was recorded in treatment C5 (3.67 and 8.06%), whereas significantly maximum PLW was observed in the treatment C7 i.e., Control (5.04 and 9.06%). Among the varietal treatments (V1= Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum PLW was recorded in treatment V2 (3.63 and 6.90%), whereas significantly maximum PLW was observed in the treatment V3 (5.55 and 12.04%). In the interaction between post-harvest treatments and varieties minimum PLW was recorded in the treatment V2 (3.05 and 6.29%) in combination with C5. The maximum PLW was noted in V3 (6.25 and 13.73%) in combination with C7 after 2 and 4 DAS respectively. After 8 DAS, among 7 post-harvest treatments, 3 treatments were spoiled *viz*.C1, C2 and C7. Among remaining treatments, minimum PLW was recorded in the treatment C6 (14.22%), whereas maximum PLW was recorded in the treatment C3 (14.89%) and among the varietal treatments, maximum PLW was recorded in V3 (17.70%) and minimum PLW was recorded in the V2 (12.78%) and Interaction between post-harvest treatments and varieties the minimum PLW was recorded in the treatment V2C5 (12.56%) and maximum PLW was noted in V3 C3.

Organic based products such as chitosan, *Aloe vera* gel and carnauba wax act as barriers on the fruit surface which block the lenticels partially leading to retardation of water loss and respiration. The positive effect of *Aloe vera* gel in reducing physiological loss in weight may be due to film forming properties of *Aloe vera* gel that allow the formation of water barrier between the fruit and the surrounding environment, thus preventing its external transferences, prevents moisture loss (Morillon *et al*., 2002 [15]) and control respiratory gases exchange (Valverde *et al*., 2005 [24]). The similar results were reported by Adetunjii *et al*., (2012) [1] in pineapple fruit; Brishti *et al*., (2013) [5] in papaya; Ergun and Satici (2012) [6].

Total soluble solids (°B)

The data revealed that there was a significant difference among the treatments with respect to TSS of sapota varieties during the different storage intervals. The initial TSS of sapota fruits for V1= 17.04°B, V2= 16.84°B, V3= 18.3°B. Among the 7 different post-harvest treatments, significantly minimum TSS was recorded in treatment C5 (18.21°B and 20.38°B), whereas significantly maximum TSS was observed in the treatment C7 i.e., Control (20.58°B and 22.30°B) followed by C2 (19.86°B and 22.07°B). Among the varietal treatments (V1=Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum TSS was recorded in treatment V2 (17.90°B and 19.17°B), whereas significantly maximum TSS was observed in the treatment V3 (19.96°B and 22.68°B). Interaction between post-harvest treatments and varieties the minimum TSS was recorded in the treatment V2 (17.29°B and 18.64°B) in combination with C5. The maximum TSS was noted in V3 (21.84°B and 23.57°B) in combination with C7 after 2 and 4 DAS respectively. After 8 DAS, among 7 post-harvest treatments, 3 treatments were spoiled *viz*.C1, C2 and C7. Among 4 remaining treatments, minimum TSS was recorded in the treatment C6 (21.31°B), whereas maximum TSS was recorded in the treatment C3 (22.21°B). Among the varietal treatments, maximum TSS was recorded in V1 (23.87°B) and minimum TSS was recorded in the V2 (19.73°B). Interaction between post-harvest treatments and varieties was the maximum TSS was recorded in the treatment V1 (24.42°B) in combination with C5. The minimum TSS was noted in V2 (19.16°B) in combination with C6. After 10 DAS, one variety (V3) completely got spoiled irrespective of post-harvest treatment and among other combinations highest TSS was noted in V1 (24.05°B) in combination with C5 and lowest TSS was noted in V2 (18.85°B) in combination with C5.

The total soluble solids act as a rough index of the amount of sugars present in fruits, as sugars constitute about 80-85 per cent of total soluble solids. The increase in TSS during storage may be due to breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars. The minimum TSS at all the days of storage was observed in the treatment C5 (*Aloe vera* gel: Distilled water (V/V) (1:1)), C3 (Carnauba wax 25%), C4 (*Aloe vera* gel: Distilled water (V/V) (2:1)) and C4 (Carnauba wax 50%) when compared to all other treatments. Comparatively, delayed increase in TSS over the storage period in the *Aloe vera* gel and carnauba wax treated fruits could be attributed to delayed conversion of starch to sugars which in turn is due to the effect of surface coatings. Similar results with *Aloe vera* coating created a modification of the internal atmosphere, as modified atmosphere packaging resulted in delayed ripening changes and sugar synthesis in fruits (Martinez *et al*., 2006 [14]). Similar results were reported by Marpudi *et al*., (2013) [13] in fig and Shirin and Asghar (2014) [20] in grapes. Further, similar results with wax application were noticed by Sariful *et al*., (2001) [19] in banana; Singh *et al*., (2012) [23] in mango; Mahajan and Rupinder (2014) [11] and Mahajan *et al*., (2013) [10] in kinnow mandarin.

Titratable acidity (%)

The titratable acidity was expressed in terms of malic acid as percentage on fresh pulp weight basis of sapota fruits. As evident from the treatment means, titratable acidity was a decreasing trend with the increase in storage period irrespective of the treatments. The initial titratable acidity of sapota fruits for V1= 0.22%, V2= 0.23%, V3=0.19%. The results indicate that there were significant differences between the treatments with respect to days after storage (DAS) of sapota fruits. Among the 7 different post-harvest treatments, significantly minimum titratable acidity was recorded in treatment C7 (0.19% and 0.18%), whereas significantly maximum titratable acidity was observed in the treatment C5 (0.24% and 0.22%). Among the varietal treatments (V1=Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum titratable acidity was recorded in treatment V3 (0.19% and 0.17%), whereas significantly maximum titratable acidity was observed in the treatment V2 (0.24% and 0.22%). Interaction between post-harvest treatments and varieties the minimum titratable acidity was recorded in the treatment V3 (0.17% and 0.15%) in combination with C7. The maximum titratable acidity was noted in V2 (0.26% and 0.25%) in combination with C3 after 2 and 4 DAS respectively. After 8 DAS, among 7 post-harvest treatments, 3 treatments were spoiled *viz*.C1, C2 and C7. Among 4 remaining treatments, minimum titratable acidity was recorded in the treatment C4 and C3 (0.18% each), whereas maximum titratable acidity was recorded in the treatment C5 and C6 (0.19% each). Among the varietal treatments, maximum titratable acidity was recorded in V2 (0.20%) and minimum titratable acidity was recorded in the V3 (0.14%). Interaction between post-harvest treatments and varieties the minimum titratable acidity was recorded in the treatment V3 (0.14%) in combination with C3. The maximum titratable acidity was noted in V2 (0.22%) in combination with C3. After 10 DAS, one variety (V3) completely got spoiled irrespective of post-harvest treatment and among other combinations highest titratable acidity was noted in V2 (0.19%) in combination with C3 and lowest titratable acidity was noted in V1 (0.17%) in combination with C6.

General declining trend in titratable acidity was noticed in sapota in all the treatments with advancement in storage period. The decrease in acidity in the fruits during the storage is because of the fact that organic acid might be utilized rapidly in respiration or conversion of acid into sugar. These results are in parallel to the findings of Mahajan *et al*., (2005) in kinnow. The maximum acidity was observed in C5 (*Aloe vera* gel: Distilled water (V/V) (1:1)), C3 (Carnauba wax 25%), C4 (*Aloe vera* gel: Distilled water (V/V) (2:1)) and C4 (Carnauba wax 50%) on most of the days during storage. However, the untreated fruits recorded rapid decrease in titratable acidity at the end of 8 DAS. While, fruits treated with *Aloe vera* gel and carnauba wax recorded minimum decreased in the titratable acidity. This is because of the slow ripening changes in the treated sapota fruits during the storage. The authors Arowora *et al*., (2013) [2] in oranges; Shweta *et al*., (2014) [21] in grape berries; Ergun and Satici, (2012) [6] in 'Granny Smith' and Marpudi *et al*., (2011) [12] observed delayed decrease in acidity in *Aloe vera* treated fruits.

Total sugars (%)

Total sugars content increased as the storage period progressed and then decreased. The initial total sugar of different sapota varieties were V1= 7.63%, V2= 7.19%, V3= 8.74%. The results indicate that there were significant differences between the treatments with respect to days after storage of sapota fruits. Among the 7 different post-harvest treatments, significantly minimum total sugar was recorded in treatment C5 (7.51% and 8.40%), whereas significantly maximum total sugar was observed in the treatment C7

(8.52% and 9.55%). Among the varietal treatments (V1=Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum total sugar was recorded in treatment V2 (7.25% and 8.13%), whereas significantly maximum total sugar was observed in the treatment V3 (8.92% and 9.95%) after 2 and 4 DAS respectively. Interaction between post-harvest treatments and varieties the minimum total sugar was recorded in the treatment V2 (6.74% and 7.51%) in combination with C5. The maximum total sugar was noted in V3 (9.46% and 10.35%) in combination with C7. After 8 DAS, among 7 post-harvest treatments, 3 treatments were spoiled *viz*.C1, C2 and C7. Among 4 remaining treatments, minimum total sugar was recorded in the treatment C6 (9.10%), whereas maximum total sugar was recorded in the treatment C3 (9.76%). Among the varietal treatments, maximum total sugar was recorded in V1 (10.32%) and minimum total sugar was recorded in the V2 (8.55%). Interaction between post-harvest treatments and varieties was the minimum total sugar was recorded in the treatment V2 (8.03%) in combination with C6. The maximum total sugar was noted in V1 (10.64%) in combination with C3 at 8 DAS. After 10 DAS, one variety (V3) completely got spoiled irrespective of post-harvest treatment and among other combinations highest total sugar was noted in V1 (10.39%) in combination with C5 and lowest total sugar was noted in V2 (8.21%) in combination with C5.

The minimum total sugars at all the days of storage was observed in the treatment C5 (*Aloe vera* gel: Distilled water (V/V) (1:1)), C3 (Carnauba wax 25%), C4 (*Aloe vera* gel: Distilled water (V/V) (2:1)) and C4 (Carnauba wax 50%) when compared to all other treatments. Comparatively, delayed increase in total sugars over the storage period in the *Aloe vera* gel and carnauba wax treated fruits could be attributed to delayed conversion of starch to sugars which in turn is due to the effect of surface coatings. Similar results with *Aloe vera* coating created a modification of the internal atmosphere, as modified atmosphere packaging resulted in delayed ripening changes and sugar synthesis in fruits (Martinez *et al*., 2006 [14]). Similar results were reported by Shirin and Asghar (2014) [20] in grapes, Marpudi *et al*., (2013) [13] in fig, Sariful *et al*., (2001) [19] in banana; Waskar and Gaikwad (2005) [25] and Singh *et al*., (2012) [23] in mango; Bishnoi *et al*., (2008) [4] in apple fruits and Sidhu *et al*., (2009) [22] in pear fruits; Mahajan *et al*., (2013) [10] and Mahajan and Rupinder (2014) [11] in kinnow mandrin.

Ascorbic acid (mg/100 g)

A gradual decrease in ascorbic acid content was observed in sapota during storage period. The initial ascorbic acid of sapota fruits for V1= 13.08 mg/100 g, V2=12.52 mg/100 g, V3=13.15 mg/100 g. The results indicate that there were significant differences between the treatments with respect to days after storage (DAS) of sapota fruits. Among the 7 different post-harvest treatments, significantly minimum ascorbic acid was recorded in treatment C7 (11.20 and 9.46 mg/100 g), whereas significantly maximum ascorbic acid was observed in the treatment C5 (12.28 and 11.22 mg/100 g). Among the varietal treatments (V1=Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum ascorbic acid was recorded in treatment V3 (11.51 and 9.82 mg/100 g), whereas significantly maximum ascorbic acid was observed in the treatment V1 (12.44 and 11.08 mg/100 g). Interaction between post-harvest treatments and varieties the minimum ascorbic acid was recorded in the treatment V2 (10.94 and 8.78 mg/100 g) in combination with C7. The maximum ascorbic acid was noted in V1 (12.93 and11.87 mg/100 g) in combination with C5 after 2 and 4 DAS respectively. After 8 DAS, among 7 post-harvest treatments, 3 treatments were spoiled *viz*.C1, C2 and C7. Among 4 remaining treatments, minimum ascorbic acid was recorded in the treatment C4 (7.60 mg/100 g), whereas maximum ascorbic acid was recorded in the treatment C3 (8.52 mg/100 g). Among the varietal treatments, maximum ascorbic acid was recorded in V1 (8.68 mg/100 g) and minimum ascorbic acid was recorded in the V2 (7.90 mg/100 g). Interaction between post-harvest treatments and varieties the minimum ascorbic acid was recorded in the treatment V2 (7.53 mg/100 g) in combination with C4. The maximum ascorbic acid was noted in V1 (9.52 mg/100 g) in combination with C3 at 8 DAS. After 10 DAS, one variety (V3) completely got spoiled irrespective of post-harvest treatment and among other combinations highest ascorbic acid was noted in V1 (8.88 mg/100 g) in combination with C3 and lowest ascorbic acid was noted in V2 (6.98 mg/100 g) in combination with C3.

Normal declining trend in ascorbic acid was noticed in sapota in all the treatments with advancement in storage period. The decrease in ascorbic acid in the fruits during the storage is because of the fact that organic acid might be utilized rapidly in respiration or conversion of acid into sugar. These results are similar to the findings of Paul (1982) in soursop; Patel *et al*., (2011) and Swati and Bisen (2012) in custard apple. The maximum ascorbic acid was observed in C5 (*Aloe vera* gel: Distilled water (V/V) (1:1)), C3 (Carnaubawax 25%), C4 (*Aloe vera* gel: Distilled water (V/V) (2:1)) and C4 (Carnauba wax 50%) on most of the days during storage. However, the untreated fruits recorded rapid decrease in ascorbic acid at the end of 8 DAS. While, fruits treated with *Aloe vera* gel and carnauba wax recorded minimum decreased in the titratable acidity. This is because of the slow ripening changes in the treated sapota fruits during the storage. The authors Shweta *et al*., (2014) [21] in grape berries, Ergun and Satici, (2012) [6] in 'Granny Smith' Sariful *et al*., (2001) [19] in banana and Huigang *et al*., (2011) [7] in pineapple.

Decay per cent

Irrespective of the treatments, decay per cent of sapota fruits increased as the storage duration progressed in all the treatments.

After 4 DAS sapota fruits start to decay. Among the 7 different post-harvest treatments, significantly minimum decay per cent was recorded in treatment C5 (2.22%), whereas significantly maximum decay per cent was observed in the treatment C7 (18.88%) after 4 DAS. Among the varietal treatments (V1=Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum decay per cent was recorded in treatment V2 (1.90%), whereas significantly maximum decay per cent was observed in the treatment V3 (18.57%). Interaction between post-harvest treatments and varieties was found significant. The maximum decay per cent was noted in V3 C7 (36.66%). After 6 DAS, among different post-harvest treatments V3 lost its keeping quality in C1 and C7. Among treatments, maximum decay per cent was recorded in the treatment C7 (25.00%) and minimum decay per cent was recorded in the treatment C5 (10.00%) after 6 DAS. Among the varietal treatments (V1=Kalipatti, V2=Cricket Ball and V3=Pala), significantly minimum decay per cent was recorded in treatment V2 (11.90%), whereas significantly maximum decay per cent was observed in the treatment V3 (28.00%) after 6 DAS. Interaction between post-harvest treatments and varieties the minimum decay per cent was

recorded in the treatment V1 (33.00%) in combination with C5 and C3. The maximum decay per cent was noticed in V3 (36.66%) in combination with C2. After 8 DAS, among 7 post-harvest treatments 3 treatments were spoiled *viz.* C1, C2 and C7. Among remaining treatments, minimum decay per cent was recorded in the treatment C6 (18.33%), whereas maximum decay per cent was recorded in the treatment C3 (31.11%) at 8 DAS. Among the varietal treatments, maximum decay per cent was recorded in V3 (49.99%) and minimum decay per cent was recorded in the V1 (14.16%). Interaction between post-harvest treatments and varieties the minimum decay per cent was recorded in the treatment V1C5 (10.00%) and the maximum decay per cent was noted in V3 C3 (56.66%). After 10 DAS, one variety (V3) completely decayed irrespective of post-harvest treatment and among other treatment combinations highest decay per cent was recorded in V1 and V2 (36.66% each) in combination with C3 and C6.

Microbial spoilage (decay) is a major constraint in extending the shelf life of the fruits during storage. Microorganisms multiply and infect the fruit surface when congenial conditions prevail. Post-harvest application of plant based extract *Aloe vera* gel, carnauba wax and chitosan to control decay is common practice followed in preservation of many fruits and vegetables. The results on per cent decay of sapota fruits indicated significant differences among the treatments. Minimum decay percentage was recorded in C5 (*Aloe vera* gel: Distilled water (V/V) (1:1)) and C3 (Carnauba wax 25%) is due to antifungal nature of these two extract effectively inhibited the decay caused by microorganisms. Lesser decay in edible coating of *Aloe vera* gel on sapota fruits may be due to antimicrobial properties of *Aloe vera* (Valverde *et al*., 2005 [24]). Shweta *et al*., (2014) [21] reported reduced bacterial, fungal count in *Aloe vera* gel coating of grape berries. The results of the present study also corroborate the results of Sai *et al*., (2013) [18] in fig and Asghari *et al*., (2013) [3] in sweet cherry.

Shelf life

Among the 7 different post-harvest treatments, significantly minimum shelf life was recorded in control i.e., C 7 (5.88 days), whereas significantly maximum shelf life was observed in the treatment C 5 (9.33 days). Among the varietal treatments (V 1 =Kalipatti, V 2 =Cricket Ball and V 3 =Pala), significantly minimum shelf life was recorded in treatment V 3 (6.33 days), whereas significantly maximum shelf life was observed in the treatment V 2 (8.28 days). Interaction between post-harvest treatments and varieties was found significant. The minimum shelf life was recorded in the treatment V 3 (5 days) in combination with C 7. The maximum shelf life was noted in V 1 and V 2 (10 days each) in combination with C 5 and C 3.

Aloe vera act as semi-permeable membrane and it prevents the oxidation reaction and reduces the transpiration and respiration rate (Asghari *et al*., 2013 [3]). Similar result with respect to *Aloe vera* gel was recorded by Shweta *et al*. (2014) [21] in grape berries; Adetunjii *et al*., (2012) [1] in pineapple and Shirin and Asghar, (2014) [20] in grapes. Maximum shelf life of wax treated fruits might be due to modified atmospheric conditions created by wax coating, which may decrease respiration and eventually catabolism of soluble solids including sugars and organic acids. These result supported by Jeong *et al*., (2003) [8] in avocado; Mahajan and Rupinder (2014) [11] in kinnow fruits; Mahajan *et al*., (2013) [10] in Kinnow mandarin; Navale *et al*., (2010) [16] in pomegranate.

Table 1: Effect of post-harvest treatments on physiological loss in weight (%) of different varieties under ambient storage condition

Treatments	Days after storage																			
	2				4				6				8				10			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
C_1	3.85	3.83	5.87	4.52	7.73	7.17	12.15	9.01	12.83	11.54	*	12.18	*	*	*	*	*	*	*	*
C_2	4.11	4.01	6.13	4.75	8.43	7.35	13.27	9.68	13.18	11.83	17.14	14.05	*	*	*	*	*	*	*	*
C_3	3.38	3.17	4.97	3.84	7.38	6.53	10.92	8.27	10.59	8.91	15.02	11.51	14.17	12.64	17.88	14.89	17.73	16.36	*	17.04
C_4	3.74	3.64	5.51	4.30	7.41	6.85	11.89	8.72	12.80	10.64	16.16	13.20	15.70	13.16	*	14.43	*	*	*	*
C_5	3.12	3.05	4.84	3.67	7.21	6.29	10.67	8.06	10.45	8.67	14.15	11.09	13.89	12.56	17.52	14.66	17.00	15.84	*	16.42
C_6	3.54	3.42	5.23	4.06	7.42	6.68	11.65	8.58	12.22	9.13	15.61	12.32	15.68	12.76	*	14.22	19.05	*	*	19.05
C_7	4.62	4.25	6.25	5.04	8.71	7.43	13.73	9.96	13.58	12.76	*	13.17	*	*	*	*	*	*	*	*
Mean	3.77	3.63	5.55		7.75	6.90	12.04		12.24	10.50	15.61		14.86	12.78	17.7		17.92	16.10	*	
For Comparing The Means	Sem±		CD At 5%		Sem±		CD At 5%		Sem±		CD At 5%		Sem±		CD At 5%		Sem±		CD At 5%	
Treatments (C)	0.002		0.005		0.002		0.007		0.002		0.005		0.001		0.003		-		-	
Varieties (V)	0.001		0.003		0.002		0.004		0.001		0.003		0.001		0.002		-		-	
Interactions (C×V)	0.003		0.009		0.004		0.012		0.003		0.008		0.002		0.006		-		-	

* No observation was recorded as the fruits lost their keeping quality.

C_1: Chitosan 0.5% C_4: Carnauba wax 50% C_7: Control V_1: Kalipatti

C_2: Chitosan 1% C_5: *Aloe vera* gel: Distilled water (V/V) (1:1) V_2: Cricket Ball

C_3: Carnauba wax 25% C_6: *Aloe vera* gel: Distilled water (V/V) (2:1) V_3: Pala

Table 2: Effect of post-harvest treatments on total soluble solids (°B) of different varieties under ambient storage condition

Treatments	2 DAS				4 DAS				6 DAS				8 DAS				10 DAS			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
C_1	20.13	18.07	19.95	19.38	23.40	19.37	23.07	21.95	23.33	19.57	*	21.45	*	*	*	*	*	*	*	*
C_2	21.24	18.23	20.12	19.86	23.37	19.53	23.32	22.07	16.27	19.84	23.15	19.75	*	*	*	*	*	*	*	*
C_3	18.60	17.43	19.53	18.52	20.72	18.87	22.42	20.67	21.17	19.62	22.90	21.23	24.13	19.94	22.55	22.21	23.93	19.24	*	21.58
C_4	19.96	17.97	19.74	19.22	21.27	19.04	22.61	20.97	22.40	19.95	23.15	21.83	23.45	20.41	*	21.93	*	*	*	*
C_5	18.07	17.29	19.26	18.21	20.67	18.64	21.82	20.38	21.01	19.50	22.65	20.90	24.42	19.42	21.52	21.78	24.05	18.85	*	21.45
C_6	19.70	17.85	19.31	18.95	21.17	18.91	21.95	20.68	21.85	19.31	22.86	21.34	23.47	19.16	*	21.31	23.13	*	*	23.13
C_7	21.43	18.46	21.84	20.58	23.50	19.83	23.57	22.30	22.86	19.57	*	21.21	*	*	*	*	*	*	*	*
Mean	19.87	17.90	19.96		22.02	19.17	22.68		21.27	19.56	22.94		23.87	19.73	22.03		23.70	19.04	*	
For comparing the means	SEm±			CD at 5%	SEm±		CD at 5%		SEm±			CD at 5%	SEm±		CD at 5%		SEm±		CD at 5%	

Treatments (C)	0.002	0.006	0.009	0.025	0.84	2.41	0.002	0.006	-	-
Varieties (V)	0.001	0.004	0.006	0.016	0.55	1.57	0.001	0.004	-	-
Interactions (C×V)	0.004	0.010	0.015	0.044	1.45	4.17	0.004	0.010	-	-

Initial value of total soluble solids: V_1=17.04°B, V_2=16.84°B, V_3=18.30°B

* No observation was recorded as the fruits lost their keeping quality.

C_1: Chitosan 0.5% C_4: Carnauba wax 50%

C_2: Chitosan 1% C_5: *Aloe vera* gel: Distilled water (V/V) (1:1)

C_3: Carnauba wax 25% C_6: *Aloe vera* gel: Distilled water (V/V) (2:1)

NOTE: DAS – Days after Storage

C_7: Control V_1: Kalipatti

V_2: Cricket Ball

V_3: Pala

Table 3: Effect of post-harvest treatments on titratable acidity (%) of different varieties under ambient storage condition

Treatments	2 DAS				4 DAS				6 DAS				8 DAS				10 DAS			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
C_1	0.22	0.23	0.21	0.22	0.21	0.21	0.19	0.20	0.20	0.20	*	0.24	*	*	*	*	*	*	*	*
C_2	0.21	0.22	0.21	0.22	0.19	0.20	0.20	0.20	0.18	0.19	0.19	0.19	*	*	*	*	*	*	*	*
C_3	0.24	0.26	0.19	0.23	0.22	0.25	0.17	0.21	0.21	0.23	0.16	0.20	0.19	0.22	0.14	0.18	0.18	0.19	*	0.18
C_4	0.23	0.24	0.18	0.22	0.21	0.22	0.16	0.20	0.19	0.21	0.15	0.18	0.17	0.19	*	0.18	*	*	*	*
C_5	0.25	0.26	0.20	0.24	0.23	0.24	0.18	0.22	0.22	0.23	0.17	0.21	0.20	0.20	0.15	0.19	0.18	0.18	*	0.18
C_6	0.24	0.25	0.18	0.22	0.22	0.23	0.17	0.21	0.20	0.22	0.16	0.20	0.19	0.20	*	0.19	0.17	*	*	0.17
C_7	0.20	0.21	0.17	0.19	0.19	0.20	0.15	0.18	0.17	0.19	*	0.18	*	*	*	*	*	*	*	*
Mean	0.23	0.24	0.19		0.21	0.22	0.17		0.21	0.21	0.17		0.19	0.20	0.14		0.18	0.18	*	
For comparing the means	SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%	
Treatments (C)	0.002		0.006		0.002		0.006		0.002		0.005		0.001		0.004		-		-	
Varieties (V)	0.001		0.004		0.001		0.004		0.001		0.003		0.001		0.002		-		-	
Interactions (C×V)	0.003		0.010		0.003		0.010		0.003		0.009		0.002		0.007		-		-	

Initial value of titrable acidity: V_1=0.22%, V_2=0.23%, V_3=0.19%

* No observation was recorded as the fruits lost their keeping quality.

C_1: Chitosan 0.5% C_4: Carnauba wax 50%

C_2: Chitosan 1% C_5: *Aloe vera* gel: Distilled water (V/V) (1:1)

C_3: Carnauba wax 25% C_6: *Aloe vera* gel: Distilled water (V/V) (2:1)

NOTE: DAS – Days after Storage

C_7: Control V_1: Kalipatti

V_2: Cricket Ball

V_3: Pala

Table 4: Effect of post-harvest treatments on total sugar (%) of different varieties under ambient storage condition

Treatments	2 DAS				4 DAS				6 DAS				8 DAS				10 DAS			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
C_1	8.03	7.34	8.97	8.11	9.26	8.36	10.11	9.24	9.08	8.45	*	8.76	*	*	*	*	*	*	*	*
C_2	8.17	7.52	9.22	8.31	9.15	8.54	10.14	9.28	8.85	8.92	10.08	9.28	*	*	*	*	*	*	*	*
C_3	7.42	6.91	8.68	7.67	8.67	7.68	9.75	8.70	9.35	8.12	10.12	9.20	10.64	8.77	9.87	9.76	9.12	8.43	*	8.77
C_4	7.91	7.27	8.83	8.01	8.93	8.14	10.06	9.04	9.75	8.62	10.53	9.63	10.04	8.83	*	9.43	*	*	*	*
C_5	7.25	6.74	8.52	7.51	8.42	7.51	9.27	8.40	9.07	7.83	9.86	8.92	10.42	8.56	9.63	9.54	10.39	8.21	*	9.30
C_6	7.74	7.13	8.75	7.87	8.79	7.97	9.98	8.91	9.42	8.25	10.37	9.35	10.17	8.03	*	9.10	9.82	*	*	9.82
C_7	8.26	7.85	9.46	8.52	9.57	8.72	10.35	9.55	9.25	8.46	*	8.85	*	*	*	*	*	*	*	*
Mean	7.83	7.25	8.92		8.97	8.13	9.95		9.25	8.38	10.19		10.32	8.55	9.75		9.77	8.32	*	
For comparing the means	SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%	
Treatments (C)	0.002		0.006		0.002		0.005		0.003		0.008		0.001		0.004		-		-	
Varieties (V)	0.001		0.004		0.001		0.003		0.002		0.005		0.001		0.002		-		-	
Interactions (C×V)	0.003		0.010		0.003		0.009		0.005		0.014		0.002		0.007		-		-	

Initial value of total sugar: V_1=7.63%, V_2=7.19%, V_3=8.74%

* No observation was recorded as the fruits lost their keeping quality.

C_1: Chitosan 0.5% C_4: Carnauba wax 50%

C_2: Chitosan 1% C_5: *Aloe vera* gel: Distilled water (V/V) (1:1)

C_3: Carnauba wax 25% C_6: *Aloe vera* gel: Distilled water (V/V) (2:1)

NOTE: DAS – Days after Storage

C_7: Control V_1: Kalipatti

V_2: Cricket Ball

V_3: Pala

Table 5: Effect of post-harvest treatments on ascorbic acid (mg/100g) of different varieties under ambient storage condition

Treatments	2 DAS				4 DAS				6 DAS				8 DAS				10 DAS			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
C_1	12.33	11.52	11.50	11.79	10.57	10.43	9.71	10.24	8.93	9.25	*	9.09	*	*	*	*	*	*	*	*
C_2	12.23	11.35	11.46	11.68	9.73	10.12	9.67	9.84	8.41	9.57	9.36	9.11	*	*	*	*	*	*	*	*
C_3	12.71	12.03	11.54	12.09	11.73	11.34	10.06	11.04	10.64	9.16	8.55	9.45	9.52	7.87	8.18	8.52	8.88	6.98	*	7.93
C_4	12.83	11.75	11.34	11.97	11.81	11.17	9.79	10.92	9.84	8.97	8.28	9.03	7.68	7.53	*	7.60	*	*	*	*
C_5	12.93	12.13	11.77	12.28	11.87	11.65	10.15	11.22	10.07	9.88	9.63	9.86	9.00	8.25	7.87	8.37	8.13	7.13	*	7.63
C_6	12.70	11.95	11.63	12.09	11.73	11.27	9.85	10.95	9.63	9.42	9.38	9.48	8.51	7.96	*	8.23	7.88	*	*	7.88
C_7	11.33	10.94	11.32	11.20	10.07	8.78	9.53	9.46	8.83	7.52	*	8.17	*	*	*	*	*	*	*	*
Mean	12.44	11.67	11.51		11.08	10.68	9.82		9.48	9.11	9.04		8.68	7.90	8.02		8.30	7.05	*	
For comparing the means	SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%	
Treatments (C)	0.074		0.211		0.002		0.006		0.002		0.006		0.001		0.004		-		-	
Varieties (V)	0.048		0.138		0.001		0.004		0.001		0.004		0.001		0.003		-		-	
Interactions (C×V)	0.127		0.365		0.004		0.011		0.004		0.010		0.002		0.007		-		-	

Initial value of ascorbic acid: V_1=13.68 mg/100g, V_2=12.52 mg/100g, V_3=13.15 mg/100g

* No observation was recorded as the fruits lost their keeping quality.

C_1: Chitosan 0.5% C_4: Carnauba wax 50%

NOTE: DAS – Days after Storage

C_7: Control V_1: Kalipatti

C_2: Chitosan 1% C_5: *Aloe vera* gel: Distilled water (V/V) (1:1)
C_3: Carnauba wax 25% C_6: *Aloe vera* gel: Distilled water (V/V) (2:1)
V_2: Cricket Ball
V_3: Pala

Table 6: Effect of post-harvest treatments on decay percent and shelf life of different varieties under ambient storage condition

Treatments	4 DAS				6 DAS				8 DAS				10 DAS				SHELF LIFE			
	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
C_1	0.00	3.33	23.33	8.88	13.33	13.33	*	13.33	*	*	*	*	*	*	*	*	6.66	7.33	5.33	6.44
C_2	3.33	3.33	23.33	10.00	16.66	16.66	36.66	23.33	*	*	*	*	*	*	*	*	6.33	7.33	6.00	6.55
C_3	0.00	0.00	10.00	3.33	3.33	6.66	23.33	11.11	13.33	23.33	56.66	31.11	26.67	36.66	*	31.66	10.00	9.66	7.66	9.11
C_4	3.33	0.00	16.67	6.66	13.33	10.00	30.00	17.77	20.00	23.33	*	21.66	*	*	*	*	8.66	8.33	6.33	7.78
C_5	0.00	0.00	6.67	2.22	3.33	6.66	20.00	10.00	10.00	16.66	43.33	23.33	23.33	33.33	*	28.33	10.00	10.00	8.00	9.33
C_6	3.33	0.00	13.33	5.55	6.66	10.00	30.00	15.55	13.33	23.33	*	18.33	36.66	*	*	36.66	9.66	8.66	6.00	8.11
C_7	13.33	6.66	36.66	18.88	30.00	20.00	*	25.00	*	*	*	*	*	*	*	*	6.00	6.66	5.00	5.88
Mean	3.33	1.90	18.57		12.38	11.90	27.99		14.16	21.66	49.99		28.88	34.99	*		8.19	8.28	6.33	
For comparing the means	SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%	
Treatments (C)	1.51		4.34		2.18		6.25		1.39		3.99		-		-		0.15		0.43	
Varieties (V)	0.99		2.84		1.42		4.09		0.91		2.61		-		-		0.10		0.28	
Interactions (C×V)	2.62		7.51		3.78		10.82		2.41		6.91		-		-		0.26		0.75	

Decay starts from 4 DAS.
* No observation was recorded as the fruits lost their keeping quality.
NOTE: DAS – Days after Storage
C_1: Chitosan 0.5% C_4: Carnauba wax 50%
C_2: Chitosan 1% C_5: *Aloe vera* gel: Distilled water (V/V) (1:1)
C_3: Carnauba wax 25% C_6: *Aloe vera* gel: Distilled water (V/V) (2:1)
C_7: Control
V_1: Kalipatti
V_2: Cricket Ball
V_3: Pala

Conclusion

Our results have shown that different postharvest treatments with organic based products [(0.5% chitosan and 1% chitosan), (Carnauba wax 25% and Carnauba wax 50%) and (*Aloe vera* gel: Distilled water (V/V) (1:1) and *Aloe vera* gel:Distilled water (V/V) (2:1)] with different sapota varieties (Kalipatti and Cricket Ball), fruits treated with *Aloe vera* gel: Distilled water (V/V) (1:1) and Carnauba wax 25% was found to be more effective in extending the shelf life of three different sapota varieties compared to all other treatments in maintaining better physico-chemical characters and organoleptic qualities at ambient conditions.

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