Original Research Article

Postharvest Treatments on Storage Life of Guava (*Psidium guajava* L.) in Himalayan Terai Region of West Bengal, India

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Abstract

Guava (*Psidium guajava* L.) is the fifth most important fruit crop of India, has a limited postharvest shelf life. This study explored the use of some postharvest treatments to extend the shelf life, post-harvest disease incidence and to assess the physico-chemical changes of fruits during storage and to study the effect of seasonal variation on quality and storage life of guava fruits (cv.L-49). Fully mature but green guava fruits were treated with different edible coating materials, chemicals, powder formulation of bio-control agent, hot water, and control. On the rainy and winter season, retention percent was found maximum with paraffin liquid 10%. Physiological loss in weight was minimum with the guar gum 1% in rainy season, paraffin 5% and gum acacia 10% in winter season. Regarding other horticultural traits like total soluble solids, ascorbic acid, total sugar, reducing sugar, non-reducing sugar content etc. were recorded maximum with gum acacia 10% in rainy season and winter. From this experiment, it is concluded that winter season guava fruits could be stored well as compared to rainy season fruits. Edible coating materials showed the better results in terms of extending the shelf life of guava fruits (cv. L-49) in both rainy and winter season as well as to maintain the qualities than the other chemicals.

Keywords

Edible coatings, chemicals, bio-control agent, guava, Storage Life.

Article Info

Accepted: 24 February 2017
Available Online: 10 March 2017

Introduction

Guava (*Psidium guajava* L.), belongs to the family Myrtaceae, is the fifth most important fruits of India in terms of production during 2014-15. Guava is one of the commonest fruits liked by poor and the rich people and also known as “The Apple of Tropics” (Bose and Mitra, 2011). Guava is being grown all over the sub-tropical and tropical world due to its high dietary value and good flavor. It is a highly palatable fruit with a rich source of vitamin C (Pal *et al*., 2004) and it is a climacteric fruits (Akamine and Goo, 1979; Markado-silva *et al*., 1998); ripen rapidly after the harvest and has a short shelf life. Therefore, guava fruits are required to be managed appropriately in order to get a regulated market supply through postharvest treatments to improve the storage life. Keeping these viewpoints, the study was conducted with objectives to extend the marketable shelf life and to assess the physico-chemical changes of fruits during
storage and to study the effect of seasonal variation on quality and storage life of guava fruits cv. L-49 treated with different edible coating materials (guar gum, gum acacia, chitosan), chemicals (calcium chloride, paraffin liquid), powder formulation of bio-control agent (Pseudomonas), hot water.

**Materials and Methods**

To conduct the experiment, fully mature but green guava fruits (cv. L-49) of two successive seasons (rainy and winter) were collected from an private orchard of Coochbehar district, West Bengal, India during the year 2013 and immediately brought to the laboratory of the Department of Pomology and Postharvest Technology, at Uttar Banga Krishi Viswa vidwalya, Pundibari, Coochbehar, West Bengal, India for storage after necessary treatments. The fruits after washing in running tap water dried in the shade for few minutes. The fruits were treated with T1- CaCl2 1% (Dip in aqueous solution of calcium chloride 1% for five minutes), T2- CaCl2 2% (Dip in aqueous solution of calcium chloride 2% for five minutes), T3- Paraffin liquid 5% (Dipped for 30 seconds in 5% aqueous emulsion of liquid paraffin), T4- Paraffin liquid 10% (Dipped for 30 seconds in 10% aqueous emulsion of liquid paraffin), T5- Pseudomonas fluorescence 1% (Dipped for 5 minutes in 1% (Pseudomonas fluorescence) aqueous solution of pseudomonas), T6- Pseudomonas fluorescence 2% (Dipped for 5 minutes in 2% (Pseudomonas fluorescence) aqueous solution of pseudomonas), T7- Hot water (45°±2°C) (Immersed into hot water for 8 minutes at 45°C± 2°C in hot water bath chamber and then were hydro cooled rapidly), T8- Hot water (35°C±2°C)(Immersed into hot water for 8 minutes at 35°C ± 2°C in hot water bath chamber and then were hydro cooled rapidly), T9- Chitosan 0.5% (To prepare 500 mL of 0.5% (w/v) chitosan solution, accurate weight of 2.5 g of chitosan were dispersed in 50 mL of glacial acetic acid), T10- Chitosan 1% (To prepare 500 mL of 1% (w/v) chitosan solution, accurate weight of 5 g of chitosan were dispersed in 50 mL of glacial acetic acid), T11- Guar gum 1% (1g guar gum powder was mixed with 100 ml of water for the preparation of 1% solution), T12- Guar gum 2% (2g guar gum powder was mixed with 100 ml of water for the preparation of 2% solutions respectively), T13- Gum acacia 10% (Dissolve 100 mg of gum acacia powder in 1000 mL water. The solution was stirred with low heat, 40 °C for 30 minutes), T14- Gum acacia 20% (Dissolve 200 mg of gum acacia powder in 1000 mL water. The solution was stirred with low heat at 40 °C for 30 minutes), T15- Control (Without treatment).

A number of observations were recorded during storage period at an interval of 2 days, i.e., physical parameters of fruits like retention percent of fruits, physiological loss in weight, fruit weight loss %= (fruit weight at initial period – fruit weight at sampling period)/fruit weight at initial period × 100, diseases incidence percent (percentage of darken fruits due to fungal and mould growth), and bio-chemical parameters of fruits like total soluble solid (TSS) (recorded with the help of handrefractometer, (Mazumdar and Majumder, 2003), total sugar and reducing sugar (AOAC, 1984), ascorbic acid (Rangana, 1977).

**Statistical analysis**

Analysis of variance (one way classified data) for each parameter was performed using ProcGlm of Statistical Analysis System (SAS) software (version 9.3). Mean separation for different treatment under different parameter were performed using Least Significant Different (LSD) test (P≤ 0.05).Data transformation is done by following Gomez and Gomez (Gomez and Gomez, 1983).
Results and Discussion

Percentage of retention

Observation during storage of rainy and winter season guava fruits revealed that the retention percent (Table 1) was decreased in all the treatments as the storage period progressed. In rainy season, on 10 days after treatment, the retention percent was found highest (80.33%) with paraffin liquid 10%, followed by paraffin liquid 5% (79%), whereas, it was minimum (42%) in control. However, in winter season, on 12 days after treatment, the retention percent was found highest (86%) with paraffin liquid 10%, followed by paraffin liquid 5% (85.67%) and statistically at par with the other chemicals, whereas, it was minimum (74.67%) in control. In winter season, 12 days after treatment, the chemical property of fruits of all treatments was better but marketable quality decreased. Treatment with hot water (Wang et al., 1963) and coating with wax emulsion (Ayranci and Tunc, 2003) also increased the shelf life of mango fruits.

Weight Loss Percentage

Weight loss percentage increased significantly with the prolongation of the storage period for all treatments. Normally, the weight loss occurs during the fruit storage due to its respiratory process, the transference of humidity and some processes of oxidation (Ayranci and Tunc, 2003). In rainy season on 10 days after treatment, the physiological loss in weight was found minimum (7.15%) with guar gum 1% and statistically at par with paraffin liquid 5% (7.39%), whereas, it was maximum (10.49%) in control. However, on 12 days after treatment, the physiological loss in weight was found lowest (5.60%) with both paraffin liquid 5% and gum acacia 10% and statistically at par with the paraffin liquid 10% (5.62%) and gum acacia 20% (5.62%), whereas, it was maximum (8.00%) in control (Table 2). The reduction in weight loss was probably due to the effects of these coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates (Baldwin, 1999).

Disease incidence percent

It was found that the postharvest disease of guava was mainly due to anthracnose diseases caused by Gloeosporium psidii. The disease incidence percent was studied by visual observation from infected guava fruits. Observation during storage of rainy and winter season guava fruits revealed that the disease incidence percent (Table III) was increased in all the treatments as the storage period progressed.

In rainy season, on 10 days after treatment, the disease incidence percent was found lowest (4%) with paraffin liquid 10% which was statistically at par with paraffin liquid 5% (5%), whereas, it was maximum (26%) under control. However, in winter season, on 12 days after treatment, the disease incidence percent was found lowest (5%) with paraffin liquid 10%, whereas, it was highest (22%) under control. Passam (Passam, 1982) also reported that ‘Doodooth’ mango was highly susceptible to anthracnose but when the fruits were treated with hot water (52±2°C) containing 500-1000 mg/l benomyl the incidence of diseases was reduced.

Total soluble solids (TSS)

TSS content during winter months was higher in general as compared to fruits harvested during rainy season (Table 4). It was increased up to a certain period and there after decreased in all the treatments as the storage period progressed.
**Table 1** Effect of different treatments on fruit retention (percent)

| TREATMENTS | Days after treatments | Rainy season | Winter season |
|------------|-----------------------|--------------|--------------|
|            | 2  | 4  | 6  | 8  | 10 | 2  | 4  | 6  | 8  | 10 | 12 |
| T<sub>1</sub>- CaCl<sub>2</sub> 1% | 95.00 (77.19) | 80.66 (63.93) | 70.66 (57.21) | 59.67 (50.57) | 52.67 (46.53) | 95.00 (77.19) | 92.33 (74.07) | 90.00 (71.7) | 87.67 (69.54) | 85.00 (67.28) | 81.33 (64.5) |
| T<sub>2</sub>- CaCl<sub>2</sub> 2% | 97.00 (81.85) | 84.00 (66.51) | 70.66 (57.22) | 58.67 (50.57) | 51.67 (45.96) | 97.00 (81.85) | 93.33 (75.1) | 91.00 (72.59) | 88.00 (69.77) | 85.33 (67.5) | 82.00 (64.94) |
| T<sub>3</sub>- Paraffin liquid 5% | 100.00 (90) | 94.66 (76.73) | 90.00 (71.56) | 85.67 (67.76) | 79.00 (62.74) | 100.00 (90) | 97.00 (80.12) | 94.67 (76.66) | 92.33 (73.93) | 89.00 (70.64) | 85.67 (67.76) |
| T<sub>4</sub>- Paraffin liquid 10% | 100.00 (90) | 96.00 (69.06) | 93.33 (62) | 87.33 (56.11) | 80.33 (51.74) | 100.00 (90) | 96.67 (79.66) | 94.33 (76.27) | 92.00 (73.59) | 89.00 (70.64) | 86.00 (68.05) |
| T<sub>5</sub>- *Pseudomonas fluorescence* 1% | 95.33 (80.01) | 88.33 (70.11) | 78.33 (62.47) | 69.00 (56.27) | 56.67 (48.84) | 96.00 (78.46) | 91.33 (72.9) | 88.67 (70.35) | 86.00 (68.04) | 83.00 (65.67) | 80.00 (63.4) |
| T<sub>6</sub>- *Pseudomonas fluorescence* 2% | 96.00 (78.46) | 88.66 (70.38) | 76.33 (60.89) | 65.00 (57.33) | 54.00 (47.3) | 93.33 (77.71) | 86.33 (68.32) | 83.33 (65.95) | 81.00 (64.19) | 78.00 (62.05) | 78.33 (62.46) |
| T<sub>7</sub>- Hot water (45±2 C) | 95.33 (80.01) | 85.33 (67.52) | 70.66 (57.21) | 57.67 (49.41) | 47.33 (43.47) | 95.33 (79.97) | 92.00 (74.00) | 89.33 (71.14) | 86.33 (68.44) | 86.67 (69.24) | 82.33 (65.55) |
| T<sub>8</sub>- Hot water (35±2 C) | 97.66 (84.89) | 81.33 (64.46) | 71.66 (57.89) | 57.67 (49.41) | 44.67 (41.94) | 97.67 (84.89) | 93.67 (75.7) | 91.00 (72.73) | 88.33 (70.11) | 85.00 (67.27) | 81.00 (64.19) |
| T<sub>9</sub>- Chitosan 0.5% | 91.00 (72.59) | 82.00 (64.97) | 71.66 (57.86) | 60.00 (54.1) | 52.33 (46.34) | 97.67 (84.89) | 94.00 (76.22) | 91.33 (73.17) | 89.00 (70.78) | 86.67 (68.99) | 83.33 (66.26) |
| T<sub>10</sub>- Chitosan 1% | 93.33 (77.7) | 87.33 (69.21) | 73.66 (59.15) | 62.67 (52.34) | 45.33 (42.32) | 95.33 (80.01) | 91.33 (73.6) | 89.00 (70.93) | 86.67 (68.99) | 84.00 (66.59) | 80.67 (64.19) |
| T<sub>11</sub>- Guar gum 1% | 96.66 (83.85) | 90.66 (60.89) | 76.33 (60.89) | 64.67 (53.53) | 57.67 (49.41) | 96.67 (83.85) | 93.00 (75.26) | 90.00 (69.69) | 87.33 (69.34) | 84.00 (66.59) | 81.66 (64.82) |
| T<sub>12</sub>- Guar gum 2% | 98.66 (86.15) | 93.00 (60.89) | 76.33 (54.13) | 65.66 (51.43) | 57.67 (49.41) | 98.67 (86.15) | 95.67 (78.23) | 93.00 (74.82) | 90.00 (71.62) | 86.67 (68.6) | 84.00 (66.44) |
| T<sub>13</sub>- Gum acacia 10% | 97.66 (84.89) | 92.66 (59.38) | 74.00 (59.38) | 63.33 (52.73) | 53.00 (46.72) | 95.33 (80.01) | 92.67 (75.13) | 90.00 (71.95) | 88.67 (70.66) | 85.67 (67.89) | 82.33 (65.18) |
| T<sub>14</sub>- Gum acacia 20% | 95.33 (80.01) | 89.66 (59.38) | 74.00 (59.38) | 60.00 (50.77) | 51.67 (45.95) | 96.00 (78.46) | 93.33 (75.05) | 90.67 (72.23) | 87.67 (69.49) | 85.00 (67.24) | 82.33 (65.18) |
| T<sub>15</sub>- Control | 96.00 (78.46) | 87.33 (57.89) | 71.66 (57.89) | 56.33 (48.64) | 42.00 (40.41) | 91.00 (72.56) | 86.67 (68.62) | 83.67 (66.17) | 80.67 (63.93) | 78.00 (62.03) | 74.67 (60) |
| Least Significant Difference (P≤0.05) | 11.765 | 3.430 | 3.790 | 3.640 | 2.37 | 11.77 | 6.16 | 5.42 | 4.73 | 5.01 | 5.17 |

**Means with the same letter are not significantly different**
Table 2. Effect of different treatments on physiological loss in weight (percent)

| Treatments                  | Days after treatments | Rainy season | Winter season |
|-----------------------------|-----------------------|--------------|---------------|
|                            |                       | 2   | 4   | 6   | 8   | 10  | 2   | 4   | 6   | 8   | 10  | 12  |
|                            |                       | 2.32| 3.22| 4.63| 6.52| 8.11| 1.61| 2.46| 3.37| 4.36| 5.47| 6.75|
| T1- CaCl₂ 1%               |                       | 2.07| 3.07| 4.48| 6.26| 8.06| 1.60| 2.44| 3.35| 4.33| 5.43| 6.70|
| T2- CaCl₂ 2%               |                       | 1.51| 3.08| 4.62| 5.88| 7.39| 1.31| 2.39| 3.27| 4.23| 5.30| 5.60|
| T3- Paraffin liquid 5%     |                       | 1.68| 2.85| 4.10| 5.97| 7.65| 1.05| 2.40| 3.28| 4.24| 5.32| 5.62|
| T4- Paraffin liquid 10%    |                       | 2.08| 3.40| 5.28| 6.97| 8.99| 1.59| 2.43| 3.33| 4.31| 5.40| 6.66|
| T5- Pseudomonas fluorescence 1% |                   | 1.66| 3.39| 5.27| 6.97| 8.98| 1.61| 2.46| 3.36| 4.36| 5.47| 6.75|
| T6- Pseudomonas fluorescence 2% |                   | 2.22| 3.70| 5.03| 6.98| 9.02| 1.59| 2.42| 3.31| 4.28| 5.37| 6.62|
| T7- Hot water (45°C ± 2°C) |                       | 2.11| 3.89| 4.95| 7.11| 9.18| 1.59| 2.42| 3.32| 4.29| 5.38| 6.64|
| T8- Hot water (35°C ± 2°C) |                       | 2.19| 3.79| 4.84| 6.94| 9.12| 1.59| 2.43| 3.33| 4.31| 5.40| 6.81|
| T9- Chitosan 0.5%           |                       | 2.20| 3.35| 4.77| 7.01| 8.96| 1.59| 2.69| 3.88| 5.18| 6.38| 6.82|
| T10- Chitosan 1%            |                       | 1.40| 2.52| 3.75| 7.15| 9.18| 1.59| 2.43| 3.89| 5.20| 6.40| 6.84|
| T11- Guar gum 1%            |                       | 1.78| 3.12| 4.61| 5.89| 7.85| 1.60| 3.00| 3.93| 5.27| 6.50| 6.95|
| T12- Guar gum 2%            |                       | 2.25| 3.17| 4.76| 6.09| 8.15| 1.08| 2.39| 3.29| 4.26| 4.74| 5.60|
| T13- Gum acacia 10%         |                       | 2.24| 3.30| 4.89| 6.24| 8.15| 1.06| 2.39| 3.30| 4.27| 5.35| 5.62|
| T14- Gum acacia 20%         |                       | 2.54| 4.31| 6.31| 8.18| 10.49| 2.39| 3.27| 4.24| 5.30| 6.54| 8.00|
| Least Significant Difference (P≤0.05) |           | 0.40| 0.36| 0.35| 0.71| 0.60| 0.38| 0.50| 0.43| 0.10| 0.25| 0.17|

**Means with the same letter are not significantly different**
Table 3: Effect of different treatments on disease incidence (percent)

| Treatments                     | Rainy season | Days after treatments | Winter season |
|--------------------------------|--------------|-----------------------|---------------|
|                                | 2   | 4    | 6    | 8    | 10   | 2   | 4    | 6    | 8    | 10   | 12  |
| T₁⁺ CaCl₂ 1%                   | 1(3.33)a | 6(14.2)a | b    | 11(19.62)a | 16(23.56)a | ab  | 21(27.2)a | 6ab  | 1(3.3)a | 4(11.74)a | ab cd | 9(17.02)a | 12(20.51)a | ab    | 16(23.83)a | b    | 20(26.56)a | ab  |
| T₂⁺ CaCl₂ 2%                   | 1(3.33)a | 5(12.8)a | ab   | 10(18.20)a | 15(22.23)a | ab  | 20(26.45)a | ab   | 1(3.3)a | 4(11.77)a | ab cd | 7(15.26)a | 11(18.86)a | abc   | 13(21.30)a | bc   | 16(23.49)a | bc   |
| T₃⁻ Paraffin liquid 5%         | 0(0)a  | 0(0)e  | 0(0)c | 1(3.33)e  | 5(12.8)e  | 0(0)a | 0(0)f  | 0(0)d | 1(3.33) | 4(10.96)ef | 7(15.18) | fgh  |
| T₄⁻ Paraffin liquid 10%        | 0(0)a  | 0(0)e  | 0(0)c | 1(3.33)e  | 4(11.38)e | 0(0)a | 0(0)f  | 0(0)d | 1(3.33) | 3(7.76)3f  | 5(13.11) | h    |
| T₅⁻ Pseudomonas fluorescence 1%| 0(0)a  | 2(4.73)cdde | 2(4.73)c | 6(14.2)cd | 10(18.4)4d | 0(0)a | 0(0)f  | 2(6.65)bc | 4(9.42)ef | 7(15.29)de | 10(17.8)2e | fg    |
| T₆⁻ Pseudomonas fluorescence 2%| 0(0)a  | 0(0)e  | 0(0)c | 4(11.38)d | 10(18.20)d | 0(0)a | 0(0)f  | 0(0)d | 1(3.33) | 4(10.96)ef | 7(14.90) | gh   |
| T₇⁻ Hot water (45°±2°C)         | 0(0)a  | 2(6.65)abcd | 5(12.78)b | 11(19.62)bc | 21(27.26)ab | 0(0)a | 2(6.65)5cef | 5(12.78)ab | 10(18.42)abcd | 15(22.52)ab | 18(24.7)abc | |
| T₈⁻ Hot water (35°±2°C)         | 1(3.33)a | 6(14.2)ab | 11(19.62)ja | 14(21.97)ab | 22(27.93)ab | 1(3.3)3a | 6(14.2)ab | 10(18.58)ja | 13(21.33)ab | 16(23.80)ab | 19(26.1)abc | |
| T₉⁻ Chitosan 0.5%               | 2(6.65)a | 5(12.78)abc | 10(18.44)ab | 16(23.56)ab | 23(28.63)ab | 1(3.3)3a | 2(4.30)edef | 2(4.73)cd | 5(12.8)cd | 8(16.36)cd | 11(19.2)2de | |
| T₁₀⁻ Chitosan 1%                | 1(3.33)a | 5(12.78)abc | 10(18.44)ab | 15(22.76)ab | 19(25.82)ab | 0(0)a | 0(0)f  | 0(0)d | 4(11.38)cd | 8(16.36)cd | 11(18.91)1def | |
| T₁₁⁻ Guar gum 1%                | 1(3.33)a | 4(9.47)abcd | 8(15.38)ab | 13(20.90)ab | 18(24.55)bc | 1(3.33)3a | 3(7.63)bced | 6(14.2)a | 11(19.09)abc | 14(22.14)ab | 18(25.0)6abc | |
| T₁₂⁻ Guar gum 2%                | 1(3.33)a | 2(4.73)cede | 5(12.8)b | 10(18.20)bc | 17(23.85)bc | 1(3.3)3a | 2(4.73)3def | 5(12.47)ab | 10(17.92)abcd | 12(20.5)2bc | 16(23.59)bc | |
| T₁₃⁻ Gum acacia 10%             | 0(0)a  | 5(12.78)abc | 9(17.02)ab | 13(21.07)ab | 18(24.84)bc | 1(3.3)3a | 5(12.78)abc | 9(17.02)a | 12(20.23)ab | 15(22.75)a | 18(24.84)abc | |
| T₁₄⁻ Gum acacia 20%             | 0(0)a  | 1(3.33)de | 2(4.73)c | 6(14.2)cd | 12(20.41)cd | 0(0)a | 1(3.33)3ef | 2(4.73)cd | 6(14.2)bcde | 12(19.89)bc | 15(22.47)cd | |
| T₁₅⁻ Control                   | 3(6.15)a | 7(15.6)a | 13(20.79)a | 20(26.52)ab | 26(30.84)ab | 2(6.65)ja | 7(14.93)a | 11(19.05)ja | 15(23.04)ab | 19(26)1.1a | 22(28.2)4a | |

Least Significant Difference (P ≤ 0.05) - 8.27 6.59 6.07 5.17 7.21 6.64 7.15 5.34 4.00

**Means with the same letter are not significantly different**
### Table 4: Changes in total soluble solids (Obrix)

| Treatments | Days after treatments | Rainy season | Winter season |
|------------|-----------------------|--------------|--------------|
|            | 2  | 4  | 6  | 8  | 10 | 2  | 4  | 6  | 8  | 10 | 12 |
| T₁ - CaCl₂ 1% | 6.86a | 7.30de | 6.43cdef | 5.85bc | d | 5.29b | c | 9.96cdef | 10.60c | d | 11.26c | def | 11.73de | fg | 10.73c | de | 10.33c | d |
| T₂ - CaCl₂ 2% | 6.77a | 7.37cd | e | 6.43cdef | 5.78cd | 5.33b | c | 10.40ab | 10.73a | bcd | 11.12d | ef | 11.66ef | g | 10.40e | 10.00 | de |
| T₃ - Paraffin liquid 5% | 7.19a | 7.73ab | 6.91abc | 6.48a | 5.86a | 10.66ab | 11.27a | b | 12.26ab | c | 11.90a | 11.13a | b |
| T₄ - Paraffin liquid 10% | 7.16a | 7.67abc | d | 6.25ab | 5.63a | 10.66ab | 11.27a | b | 12.40ab | 11.93a | 11.13a | b |
| T₅ - *Pseudomonas fluorescence* 1% | 7.01a | b | 7.30de | 6.32def | 5.97bc | 5.19c | 10.33ab | cd | 10.73a | bcd | 11.20c | def | 11.60fg | 10.99c | d | 10.06de |
| T₆ - *Pseudomonas fluorescence* 2% | 6.94a | b | 7.37cd | e | 6.54abc | de | 5.93bc | 5.29b | c | 9.93cdef | 10.40c | d | 10.84f | 11.73de | fg | 11.12bc | 10.73bc |
| T₇ - Hot water (45°±2°C) | 6.77a | b | 7.16e | 6.45bc | def | 5.74cd | 5.29b | c | 10.06bc | def | 11.00a | bc | 11.34bc | def | 11.60fg | 10.60c | de | 9.86de |
| T₈ - Hot water (35°±2°C) | 6.54a | b | 7.06e | 6.16ef | 5.68cd | 5.19c | 9.53f | 10.2dd | 10.99ef | 11.46g | 10.53de | 9.80e |
| T₉ - Chitosan 0.5% | 6.46c | 7.27de | 6.46abc | def | 5.88bc | d | 5.42b | c | 9.80cdef | 10.53cd | 11.34bc | cde | 12.00bc | def | 11.20bc | 10.80bc |
| T₁₀ - Chitosan 1% | 6.86a | b | 7.19e | 6.63abc | de | 5.88bc | d | 5.36b | c | 9.67ef | 10.40c | d | 11.12d | ef | 11.80cd | efg | 11.12bc | 10.73bc |
| T₁¹ - Guar gum 1% | 7.26a | 7.84ab | 6.96ab | 6.51a | 5.93a | 10.20ab | cde | 10.67bc | d | 11.44abc | cde | 12.13ab | cde | 11.79a | 11.06ab |
| T₁² - Guar gum 2% | 7.13a | 6.54bc | d | 6.73abc | d | 6.00bc | 5.59a | b | 10.13bc | ab | 10.73abc | d | 11.50abc | d | 12.20abc | cd | 11.60abc | 10.93b |
| T₁⁻ - Gum acacia 10% | 7.28a | 7.91a | 6.91abc | 6.53a | 5.95a | 10.80a | 11.33a | 11.90a | 12.60a | 12.00a | 11.26a |
| T₁⁴ - Gum acacia 20% | 7.25a | 7.90a | 6.98a | 6.48a | 5.86a | 10.33abc | cd | 11.00abc | 11.64abc | 12.33abc | 11.89a | 11.20ab |
| T₁₅ - Control | 6.74a | bc | 7.07e | 6.00f | 5.51d | 5.16c | 9.73def | 10.53cd | 11.20def | 11.60fg | 10.93c | d | 10.33cd |
| Least Significant Difference (P≤0.05) | 0.55 | 0.34 | 0.52 | 0.40 | 0.36 | 0.67 | 0.66 | 0.50 | 0.53 | 0.49 | 0.51 |

**Means with the same letter are not significantly different**
### Table 5: Changes in total sugar content (mg)

| Treatments                      | Days after treatments | Rainy season |                          | Winter season |                          |
|---------------------------------|-----------------------|--------------|---------------------------|---------------|---------------------------|
|                                 |                       | 2            | 4            | 6             | 8             | 10            | 12            | 2            | 4            | 6             | 8             | 10            | 12            |
| **T1**- CaCl$_2$ 1%             |                       | 4.33         | 5.11         | 4.27          | 3.76def       | 3.29d         | 6.11f         | 6.56h         | 6.88f         | 7.17bc        | 6.49e         | 6.04g         |               |
| **T2**- CaCl$_2$ 2%             |                       | 4.27d        | 5.17b        | 4.30          | 3.67ef        | 3.33d         | 6.67bc        | 6.94bcd        | 7.02d         | 7.17bc        | 6.69cd        | 6.29de        |               |
| **T3**- Paraffin liquid 5%      |                       | 4.72a        | 5.51a        | 4.77          | 4.26ab        | 3.89a         | 6.75abc       | 6.98ab        | 7.17a         | 7.27a         | 6.95ab        | 6.60ab        |               |
| **T4**- Paraffin liquid 10%     |                       | 4.66ab       | 5.53a        | 4.56          | 4.19abc       | 3.69ab        | 6.92ab        | 7.07a         | 7.23a         | 7.29a         | 6.92ab        | 6.62a         |               |
| **T5**- Pseudomonas fluorescence 1% |                  | 4.49         | 5.05b        | 4.23          | 3.83bcd       | 3.19d         | 6.83ab        | 6.91bcd        | 7.08cde       | 7.18bc        | 6.62de        | 6.27e         |               |
| **T6**- Pseudomonas fluorescence 2% |                  | 4.38         | 5.18b        | 4.35          | 3.81cde       | 3.29d         | 6.52d         | 6.84def        | 7.00e         | 7.15cd        | 6.63de        | 6.26e         |               |
| **T7**- Hot water (45° ±2°C)     |                       | 4.10e        | 5.07bc       | 4.25          | 3.65ef        | 3.30d         | 6.59cd        | 6.72g         | 7.07de        | 7.25ab        | 6.76bc        | 6.41cd        |               |
| **T8**- Hot water (35° ±2°C)     |                       | 4.33         | 5.11bc       | 4.31          | 3.86abc       | 3.16e         | 6.28ef        | 6.57h         | 6.89f         | 7.08d         | 6.66de        | 6.21ef        |               |
| **T9**- Chitosan 0.5%            |                       | 4.33         | 5.12bc       | 4.44          | 3.75def       | 3.43cd        | 6.60bc        | 6.94bcd        | 7.05de        | 7.14cd        | 6.83ab        | 6.46c         |               |
| **T10**- Chitosan 1%             |                       | 4.40         | 5.11bc       | 4.50          | 3.74def       | 3.35c         | 6.50bc        | 6.83ef         | 7.07de        | 7.14cd        | 6.74bc        | 6.48cd        |               |
| **T11**- Guar gum 1%             |                       | 4.78a        | 5.61a        | 4.80          | 4.30ab        | 3.93a         | 6.71ab        | 6.79fg         | 7.07de        | 7.11cd        | 6.82ab        | 6.33cd        |               |
| **T12**- Guar gum 2%             |                       | 4.65         | 5.49b        | 4.58          | 4.07abc       | 3.59bc        | 6.54cd        | 6.87cd         | 7.03de        | 7.12cd        | 6.65cd        | 6.40cd        |               |
| **T13**- Gum acacia 10%          |                       | 4.78a        | 5.60a        | 4.81          | 4.30a         | 3.93a         | 6.93a         | 7.01ab         | 7.17a         | 7.28a         | 6.98a         | 6.64a         |               |
| **T14**- Gum acacia 20%          |                       | 4.70         | 5.61a        | 4.80          | 4.25abc       | 3.89a         | 6.63bcd        | 6.94bcd        | 7.10bcd       | 7.24ab        | 6.99a         | 6.66a         |               |
| **T15**- Control                |                       | 4.25         | 5.00c        | 4.26          | 3.60f         | 3.13e         | 6.54cd        | 6.89cd         | 7.01de        | 7.12cd        | 6.59de        | 6.13fg        |               |
| Least Significant Difference   |                       | 0.18         | 0.15         | 0.14          | 0.45          | 0.25          | 0.23          | 0.11           | 0.09          | 0.07          | 0.22          | 0.12          |               |

**Means with the same letter are not significantly different**
**Table 6** Changes in reducing sugar content (mg)

| Treatments                          | Days after treatments | Winter season |
|-------------------------------------|-----------------------|---------------|
|                                     | 2         | 4       | 6       | 8       | 10      | 2         | 4       | 6       | 8       | 10      | 12       |
| T<sub>1</sub>- CaCl<sub>2</sub> 1% | 2.30c def | 3.03d e  | 2.30 d  | 2.04 a  | 1.70d ef | 3.15d ef  | 3.27 ef | 3.3 5a  | 3.21 e  | 3.07 d  | 3.01d   |
| T<sub>2</sub>- CaCl<sub>2</sub> 2% | 2.20d efg | 3.10c de | 2.37 cd | 2.03 a  | 1.75c de | 3.16c def | 3.26 ef | 3.3 3b  | 3.20 e  | 3.11 cd | 3.02c d |
| T<sub>3</sub>- Paraffin liquid 5%  | 2.57a     | 3.30a b  | 2.70 ab | 2.36 a  | 1.96a b  | 3.23a b   | 3.33ab c | 3.4 1a  | 3.33 c  | 3.26 c  | 3.18a   |
| T<sub>4</sub>- Paraffin liquid 10% | 2.53a b   | 3.30a b  | 2.53 ab | 2.32 a  | 1.87a bc | 3.24a b   | 3.33ab c | 3.4 2a  | 3.35 ab | 3.26 a  | 3.17a   |
| T<sub>5</sub>- Pseudomonas fluorescence 1% | 2.31b cde | 3.14c de | 2.37 cd | 2.03 a  | 1.56g    | 3.16c def | 3.26 f  | 3.3 3b  | 3.20 e  | 3.14 bc | 3.07b   |
| T<sub>6</sub>- Pseudomonas fluorescence 2% | 2.30c def | 3.10c de | 2.36 cd | 2.08 a  | 1.68e fg | 3.13f     | 3.25 f  | 3.3 3b  | 3.20 e  | 3.15 bc | 3.07b   |
| T<sub>7</sub>- Hot water (45º ± 2º C) | 2.08g     | 3.03d e  | 2.36 cd | 2.09 a  | 1.74c de | 3.15e f   | 3.26ef   | 3.3 3b  | 3.2e    | 3.13 bc | 3.05c   |
| T<sub>8</sub>- Hot water (35º ± 2º C) | 2.27c def | 3.14c de | 2.31 d  | 2.12 a  | 1.77c de | 3.15d ef  | 3.27df e | 3.3 3b  | 3.21 e  | 3.16 b  | 3.04b cd |
| T<sub>9</sub>- Chitosan 0.5%       | 2.09f g   | 3.07d e  | 2.43 cd | 2.08 a  | 1.74c de | 3.20b cde | 3.30ab cde | 3.3 5b | 3.27 c  | 3.15 bc | 3.05b c |
| T<sub>10</sub>- Chitosan 1%       | 2.20d efg | 3.00e    | 2.50 c  | 2.09 a  | 1.74c de | 3.22a cde | 3.28de f  | 3.3 3b  | 3.26 cd | 3.14 bc | 3.05b c |
| T<sub>11</sub>- Guar gum powder 1%| 2.59a     | 3.34a b  | 2.71 a  | 2.26 a  | 1.83b cde | 3.23a b   | 3.29cd ef | 3.3 4b  | 3.27 cd | 3.15 bc | 3.07b   |
| T<sub>12</sub>- Guar gum powder 2% | 2.42a bc  | 3.23b c  | 2.50 c  | 2.06 a  | 1.81b cde | 3.20b cde | 3.32ab cd | 3.3 6b  | 3.27 cd | 3.16 b  | 3.07b   |
| T<sub>13</sub>- Gum acacia 10%    | 2.60a     | 3.37a    | 2.73 a  | 2.38 a  | 1.98a    | 3.26a b   | 3.34a     | 3.4 1a  | 3.35 ab | 3.28 a  | 3.19a   |
| T<sub>14</sub>- Gum acacia 20%    | 2.40a bcd | 3.12c de | 2.50 c  | 2.00 a  | 1.76c de | 3.27a     | 3.33ab c  | 3.4 3a  | 3.36 a  | 3.27 a  | 3.18a   |
| T<sub>15</sub>- Control           | 2.17e fg  | 3.02d e  | 2.30 d  | 2.01 a  | 1.58f g  | 3.21a bcd | 3.29bc def | 3.3 3b  | 3.25 d  | 3.13 bc | 3.02c d |

**Least Significant Difference (P≤0.05)**

|          | 0.22 | 0.13 | 0.17 | 0.44 | 0.14 | 0.06 | 0.04 | 0.0 | 0.03 |

**Means with the same letter are not significantly different**
Table 7 Changes in ascorbic acid content (mg/100g of pulp)

| Treatments                      | Rainy season | Days after treatments | Winter season |
|--------------------------------|--------------|-----------------------|---------------|
|                                | 2 | 4 | 6 | 8 | 10 | 2 | 4 | 6 | 8 | 10 | 12 |
| T<sub>1</sub> CaCl<sub>2</sub> 1% | 161.57f      | 154.21h               | 149.41 ef     | 142.1 6e | 135.24 gh | 248.36c def | 243.2 5cd | 236.1 5e | 230.4 5g | 225.3 1de | 220.6 1de |
| T<sub>2</sub> CaCl<sub>2</sub> 2% | 165.17 cde   | 159.61d e             | 152.34 cd     | 147.0 0c | 140.27 de | 253.16a b   | 248.6 1a  | 242.0 0b | 236.1 6cd | 230.3 4c | 224.3 9c  |
| T<sub>3</sub> Paraffin liquid 5%| 167.24 T     | 162.00b cde           | 157.18 b      | 151.0 0b | 145.32 c  | 253.21a b   | 249.3 8a  | 245.3 2a | 240.8 4a | 236.5 1ab | 230.3 4ab |
| T<sub>4</sub> Paraffin liquid 10%| 167.00 bc    | 163.14a b             | 158.34 ab     | 152.2 4b | 146.23 bc | 253.17a b   | 248.3 1a  | 244.1 6a | 239.6 4ab | 235.6 1ab | 229.1 6ab |
| T<sub>5</sub> Pseudomonas fluorescence 1% | 164.00 de | 156.00g h              | 150.05 def    | 144.3 1de | 137.26f g | 247.00e f   | 241.2 8cd | 235.3 4ef | 230.6 1fg | 225.6 4de | 219.6 1de |
| T<sub>6</sub> Pseudomonas fluorescence 2% | 163.42 ef | 156.65f gh             | 150.82 cde    | 142.2 5e | 135.21 gh | 248.21c def | 253.3 4bc | 237.5 7d | 231.0 4fg | 226.5 4d | 220.3 1de |
| T<sub>7</sub> Hot water (45°±2°C) | 163.12 ef | 155.26h               | 148.21f       | 144.2 8de | 138.00 ef | 245.62f     | 239.2 7de | 233.6 4f | 227.3 4h | 222.6 1f | 218.1 6ef |
| T<sub>8</sub> Hot water (35°±2°C) | 166.00 bcd  | 158.36e fg            | 151.45 f      | 144.3 4de | 135.42 gh | 251.00a b   | 245.3 1bc | 240.2 1bc | 234.5 4de | 229.6 1c | 221.5 2cd |
| T<sub>9</sub> Chitosan 0.5%    | 165.16 cde  | 158.32e fg            | 152.37 cde    | 146.2 9cd | 140.28 de | 247.00e f   | 241.3 1cd | 235.0 0ef | 230.6 1fg | 224.3 5ef | 219.6 1de |
| T<sub>10</sub> Chitosan 1%    | 165.32 cde  | 159.45e f             | 153.12 c      | 147.2 6c  | 141.33 d  | 250.31a bcd | 242.3 0c | 236.3 1de | 230.0 0g | 223.0 0f | 215.6 1f |
| T<sub>11</sub> Guar gum 1%    | 168.05 ab   | 162.31b cd            | 157.61 b      | 151.3 4b | 148.36 ab | 249.31c de  | 245.3 1b  | 239.1 3c | 232.6 5ef | 226.3 5d | 222.3 1cd |
| T<sub>12</sub> Guar gum 2%    | 167.27 bc   | 163.19a b             | 158.27 ab     | 152.3 4b | 145.23 c  | 247.61d ef  | 243.2 1bc | 237.6 1d | 231.2 3de | 225.1 3de | 220.6 1de |
| T<sub>13</sub> Gum acacia 10% | 170.00 a    | 165.31a               | 160.20 a      | 155.1 5a | 150.10 a  | 250.15b cde | 245.1 6b  | 241.3 1bc | 237.6 1bc | 234.6 1b | 229.0 0b  |
| T<sub>14</sub> Gum acacia 20% | 168.05 ab   | 163.00a bc            | 158.34 ab     | 152.0 0b | 148.10 ab | 253.42a     | 249.6 1a  | 244.3 1a | 240.3 1a  | 236.1 0ab | 232.1 5a  |
| T<sub>15</sub> Control        | 167.19 bc   | 160.18c de            | 152.61 c      | 145.2 6cd | 133.28 h  | 246.00f     | 238.0 9e  | 230.6 1g | 223.0 6i | 218.0 0g | 210.3 1g  |

Least Significant Difference (P≤0.05)

2.39 | 2.37 | 2.37 | 2.37 | 3.17 | 2.33 | 1.42 | 2.16 | 1.73 | 3.13

**Means with the same letter are not significantly different

In rainy season, on 10 days after treatment, TSS was found maximum (5.95°brix) with gum acacia 10%, followed by guar gum 1% (5.93°brix) and statistically at par with paraffin liquid 5%, 10% and gum acacia 20%, whereas, it was minimum (5.16°brix) under control. Similarly, in winter season, on 12 days after treatment, it was found maximum (11.26°brix) with gum acacia 10% which was statistically at par with the gum acacia 20%, paraffin liquid 5% and 10%. The increase in TSS and sugar content 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., 1980). Kagzi lime fruits treated with coconut oil recorded minimum (8.4%) increase in TSS followed by (8.5%) liquid paraffin wax (Bisen et al., 2012).

**Total sugar (TS)**

In rainy season, on 10 days after treatment, total sugar (Table 5) content was found maximum (3.93) with guar gum 1% and gum acacia 10% and statistically at par with paraffin liquid 5% (3.89), gum acacia 20% (3.89) and paraffin liquid 10% (3.69), whereas, it was minimum(3.13) under control. However, in winter season, on 12 days after treatment, total sugar content was found maximum (6.66) with gum acacia 20% and statistically at par with gum acacia 10% (6.64), paraffin liquid 10% (6.62) and paraffin liquid 5% (6.60), whereas, it was minimum (6.04) with calcium chloride 1%.

**Reducing sugar**

In rainy season, on 10 days after treatment, reducing sugar content (Table 6) was found maximum (1.98) with gum acasia 10% and statistically at par with paraffin liquid 5% (1.96%) paraffin liquid 10% (1.87). In winter season similarly, maximum (3.19)reducing sugar content was recorded with gum acasia 10% and it was statistically at par with paraffin liquid 5% (3.18), paraffin liquid 10% (3.17) and gum acasia 20%(3.18).

**Ascorbic acid**

The ascorbic acid content (Table 7) was decreased in all the treatments as the storage period advanced. In rainy season, on 10 days after treatment, the ascorbic acid content was found highest (150.1 mg/100g of pulp) with gum acacia 10% and statistically at par with the guar gum 1% and gum acacia 20%, whereas, it was lowest (133.28mg/100g of pulp) under control. However, in winter season, on 12 days after treatment, it was found maximum (232.15mg/100g of pulp) with gum acacia 20% and statistically at par with the paraffin liquid 5% (230.34mg/100g of pulp) and 10% (229.16mg/100g of pulp), whereas, it was minimum (210.31mg/100g of pulp) under control. The ascorbic acid content (5.81 mg/100g) was more in peach fruits treated with paraffin liquid (20%) as compared to fruits under control (2.81 mg/100g) (Elham and Sawsan, 2013).

In conclusion, the fruit retention percentage in both the rainy and winter season was found maximum with paraffin liquid 10%. Physiological loss in weight was minimum in fruits treated with the guar gum 1% in rainy season and paraffin 5% and gum acacia 10% in winter season. Disease incidence was found minimum in the fruits treated with paraffin liquid 5% in both the seasons. Regarding other horticultural traits like TSS, ascorbic acid, total sugar, reducing sugar, content were recorded maximum with gum acacia 10% in rainy season guava fruits and gum acacia10% and 20% in winter season, respectively. From this experiment, it is concluded that winter season guava fruits could be store well as compared to rainy season fruits. Edible coating materials showed the better results in terms of extending the shelf life as well as the qualities of guava fruits than the other chemicals in both rainy and winter season.

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**How to cite this article:**

Piyali Dutta, Nilesh Bhowmick, Surajit Khalko, Arunava Ghosh and Swapan Kr. Ghosh. 2017. Postharvest Treatments on Storage Life of Guava (*Psidium guajava* L.) in Himalayan Terai Region of West Bengal, India. *Int.J.Curr.Microbiol.App.Sci.* 6(3): 1831-1842. doi: [https://doi.org/10.20546/ijcmas.2017.603.209](https://doi.org/10.20546/ijcmas.2017.603.209)