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# Post-harvest interventions to extend the shelf life and maintain the quality of Indian jujube cv. Umran under ambient storage conditions

## Haritha K and Anmol

**Abstract**

An experimental study was conducted to observe the effects of post-harvest treatments which extend the shelf life and maintain the quality of Indian jujube cv. Umran under ambient storage conditions. The results revealed that calcium chloride and SA significantly reduced the physiological loss in weight during ambient storage condition in Ber fruits. Application of 1.5 per cent calcium chloride on Ber fruits packed in nelton bag exhibited minimum weight loss is during storage period in ambient storage conditions. The application of $CaCl_2$ and SA significantly influenced the pulp/stone ratio under ambient storage conditions in Ber fruits. The $CaCl_2$ @ 1.5 per cent ($T_3$) was recorded maximum i.e., 11.51, 11.39, 11.10 and 10.29 pulp / stone ratio at 3rd, 6th, 9th and 12th days under ambient storage conditions, respectively. The maximum TSS was recorded under $T_3$ treatment (1.5% $CaCl_2$) i.e., 13.36, 14.56, 14.89 and 13.95 °B at 3rd, 6th, 9th and 12th days of storage, respectively. The maximum acidity i.e., 0.253, 0.232, 0.221 and 0.171 per cent was recorded in $T_3$ (1.5% $CaCl_2$) while minimum i.e., 0.189, 0.159, 0.129 and 0.108 per cent under control at 3rd, 6th, 9th and 12th days of storage period under ambient storage conditions. The application of $CaCl_2$ at the rate 1.5 per cent decreased the TSS / acid ratio of 18.33 per cent on 12th day of storage as compared to control. The reducing sugar increased during storage time up to 9th day but decreased on 12th day of storage in all treatment combinations of Ber fruits. This treatment of application of $CaCl_2$ showed an increased 68.60 per cent more reducing sugar over control at 12th day under ambient storage conditions. The maximum non reducing sugar content in Ber fruits i.e., 4.85, 5.39, 5.55 and 4.85 per cent at 3rd, 6th, 9th and 12th days of storage was recorded under $T_3$ (1.5% $CaCl_2$) during ambient storage conditions, respectively.

**Keywords:** Indian jujube, post-harvest, shelf life, ambient storage

## Introduction

The ber or Indian Jujube (*Ziziphus mauritiana* Lamk.) is an old and popular fruit native to India and China, belonging to the Rhamnaceae family and the Rhamnales order. The generic name *Ziziphus* comes from the Arabic word *Zizyphus lotus*, which is 'zizouf' (Bailey, 1947) [24]. It is the most ancient and common fruits of arid and semi-arid zones of India, also referred as poor man's fruit due to its low cost of production. The peak season of harvesting of ber [in north India] is mid-march to mid-April. Ber fruits are relatively perishable and have shelf-life of only 4-5 days at ambient temperatures (Meena *et al.*; Azam-Ali *et al.*) and overall quality of ber fruits (after harvest) depends upon storage conditions used. Due to prevalence of high temperature and low relative humidity during harvesting, fruit starts spoiling rapidly and over ripe fruits deteriorate very fast. Improving the shelf-life of the fruit, in most cases, a result of improving its storage life.

Ber fruits are consumed both fresh and dried, and are processed into a range of products such as sweets, jelly, jam, murabba, squash, and a number of other items. Dried fruits can be eaten as is, or they can be rehydrated and seasoned. Aside from the fruit's nutritional benefits, various sections of the tree are also known to have medicinal value. Fruit is thought to purify the blood and aid digestion; it also acts as an aphrodisiac, tonic, laxative, and energizing agent, as well as removing biliousness, burning sensations, and thirst. Eye sickness, cough, asthma, thirst, vomiting, burning feeling, and leucorrhea are all treated with the acrid and sweetish seeds, which also work as a tonic and aphrodisiac (Kundu *et al.*, 1989) [25].

The Ber is one of the most nutritious fruits; when completely mature, its pulp contains roughly 13-19% T.S.S. and 0.20 to 0.60 percent acidity. It, along with anola and guava, is one of the highest sources of vitamin C. It also contains a lot of protein (0.8 g / 100 g) and minerals like phosphorus (0.148%) and iron (0.54%) (Sharma *et al.*, 2002) [26].

The overall sugar content of cv. Umran fruits was 8.1% (Singh *et al.*, 1983) [27]. Among the amino acids present in the ber pulp are asparagine, aspartic acid, arginine, glutamic acid, serine, glycine, threonine, - alanine, valine, methionine, leucine, and isoleucine (Bal, 1981) [16].

One of the most essential aspects of post-harvest handling and storage of perishable fruits is preserving the fruits' post-harvest quality for a longer duration. A few methods have been explored to maintain the quality of fruits after they have been harvested. Perforated polythene sheets, film liner, waxing, pre-harvest treatment with hot water and air, growth stimulants, fungicidal dips, irradiation, and keeping at sub-atmospheric pressure are some of the techniques used. It has been shown to extend the shelf life of certain fruits after they have been harvested.

**Materials and Methods**

The present study entitled "post-harvest interventions to extend the shelf life and maintain the quality of Indian jujube cv. Umran under ambient storage conditions" is being conducted at post-harvest laboratory, Department of Horticulture, Lovely Professional University, Punjab during the academic year 2021-2022. The experiment was conducted in Completely Randomized Design (CRD), comprising of 7 treatments with three replications.

The mature Ber fruits was collected prior to the post-harvest treatment, the fruits were washed in potable water. The fruits allowed to dry in shade prior to imposition of treatments. The details of the treatments include $T_1$ ($CaCl_2$ 0.5%), $T_2$ (Cacl$_2$ 1.0%), $T_3$ ($CaCl_2$ 1.5%), $T_4$ (SA 1 mM), $T_5$ (SA 2 mM), $T_6$ (SA 3 mM), $T_7$ Control, each treatment was replicated thrice with ambient storage condition. The observations on physical and quality parameters were recorded at an interval of 3 days.

**Results and Discussion**

**Physical parameters**

**Weight loss (%)**

It was evident from the data presented in Table.1, that there was significant effect on physiological weight loss of Ber fruits treated with different post-harvest treatments. The minimum physiological loss in weight was found in Ber fruits treated with 1.5 per cent calcium chloride ($T_3$) where *i.e.*,7.21%, 11.79%, 18.01% and 28.78% physiological weight loss was recorded at 3$^{rd}$, 6$^{th}$, 9$^{th}$ and 12$^{th}$ days under ambient storage condition, respectively. On 12$^{th}$ day minimum physiological loss in weight was recorded under $T_3$ treatment which was significantly at par with $T_2$ (1.5% $CaCl_2$). The minimum physiological weight loss under $T_3$ treatment was 29.97 per cent lower as compared to control.

Whereas, maximum physiological weight loss was found under control on every 3$^{rd}$, 6$^{th}$, 9$^{th}$ and 12$^{th}$ day. Likewise, minimum weight loss was recorded under $T_3$ treatment (1.5% $CaCl_2$) which was 21.33 per cent less as compared to control. Whereas, $T_2$ (1.0% $CaCl_2$) was found at par with $T_3$ treatment under control storage condition of ber fruits.

The results revealed that calcium chloride and SA significantly reduced the physiological loss in weight during ambient storage condition in ber fruits. Application of 1.5 per cent calcium chloride on ber fruits exhibited minimum weight loss during storage period in ambient storage conditions. It was observed that minimum physiological loss in weight recorded 28.78 per cent on 12th day in ambient storage conditions.

**Spoilage (%)**

A close review of data Table.1 indicates that different post-harvest treatments significantly influenced spoilage percentage of Ber fruits. The minimum decay loss was observed under $T_3$ treatment (1.5% $CaCl_2$) with 2.11%, 10.98%, 17.17% and 40.10% after 3rd, 6th, 9th and 12th days under ambient storage conditions. Whereas, maximum decay loss was recorded in control ($T_7$) *i.e.*4.73%, 18.10%, 28.30% and 59.20% at 3rd, 6th, 9th and 12th days of storage. The minimum percentage of decay loss under $T_3$ treatment observed 22.96 per cent over control under ambient storage conditions on 12th day of storage in Ber fruits.

The results revealed that calcium chloride and SA significantly reduced the spoilage during ambient storage condition in Ber fruits. Application of 1.5 per cent calcium chloride on ber fruits exhibited minimum spoilage is during storage period. The results of the present study revealed that decay loss was observed from the 3$^{th}$ day of storage and onwards increased significantly up to 12$^{th}$ day of storage in ambient storage conditions. Application of 1.5 per cent $CaCl_2$ gave a longer storage life than the other all treatments under ambient storage conditions during the storage period. The minimum decay loss was observed 40.10 per cent on 12$^{th}$ day of storage under ambient storage conditions. The current study demonstrates that application of calcium chloride has merit in reducing spoilage in ber fruits which may be due to their positive role in decaying the senescence of fruits by maintaining cell wall integrity and thus lowering the spoilage under ambient storage conditions (Singh *et al* (2010) [28].

**Pulp to stone ratio**

It is evident from the data in Table 2 that application of $CaCl_2$ and SA significantly influenced the pulp / stone ratio under ambient storage conditions in ber fruits. The $CaCl_2$ @ 1.5 per cent ($T_3$) was recorded maximum i.e. 11.51, 11.39, 11.10 and 10.29 pulp/stone ratio at 3$^{rd}$, 6$^{th}$, 9$^{th}$ and 12$^{th}$ days under ambient storage conditions, respectively.

Whereas, the treatments $T_2$ (11.43), $T_5$ (10.88) and $T_6$ (11.06) at 3rd day and treatment $T_2$ (11.02) and $T_6$ (11.00) at 6th significantly at par with treatment $T_3$ under ambient storage conditions, respectively. The increase in pulp/stone ratio under $T_3$ was recorded by 41.74 per cent over control on 12th day under ambient storage conditions.

The pulp / stone ratio showed decreasing trend with postharvest treatments of calcium chloride and SA during the storage period under ambient storage conditions. The pulp/ stone ratio was obtained maximum in 1.5 per cent $CaCl_2$, while minimum in control up to 12 days of storage under ambient storage conditions, respectively.

It is might be due to presence of more calcium in the middle lamella. Gupta *et al.* (1984) [29] reported an increase in pulp/stone ratio in Jogia and Kaithali cultivars of ber and attributed it to higher increase in pulp as a result of food accumulation. In the present study, the sprays were started when it was still in rapid growth stage and hence calcium might have changed the metabolism of the fruits and resulted in more accumulation of food constituents in the fruits.

**Organoleptic sensory attributes**

A critical analysis of data table 2 indicated that treatments of calcium chloride and SA was significantly influenced the palatability rating during the storage period under ambient storage conditions. The maximum palatability rating i.e. 8.09, 6.89, 4.67 and 2.32 at 3rd, 6th, 9th and 12th days was recorded under treatment T3 (1.5% $CaCl_2$) which was significantly superior over control ($T_7$). The palatability rating recorded the higher 88.62 per cent in treatment $T_3$ as compared to the control at 12th day under ambient storage conditions.

The ber fruits treated with the $CaCl_2$ 1.5 per cent recorded highest score in all the sensory qualities like color, flavor, texture, and taste up to 12 days under ambient storage conditions. The results are in concurrence with due to increase in ripening and rotting at the end of storage as reported by Kumar *et al*. (1994) [30]. The deterioration in taste and flavor of ber fruits occurred at slow rates during storage at low temperature. Calcium chloride attributed to low rates of respiration and transpiration in the fruits under low temperature reported a slow fall in palatability rating of Umran ber fruits packed in polythene bags and baskets when stored at 13 ºC. Kumar *et al.* (1994) [30] reported that consumer acceptability of ber was maintained for longer period when fruits treated with calcium chloride.

**Biochemical characteristics**

**Total soluble solids (°Brix)**

Data pertaining to total soluble solids are presented in Table 3 clearly reveals that effect of different post-harvest treatments of calcium chloride and SA significantly influenced the total soluble solids during the storage period. Initially TSS was increased up to 9th day of storage that thereafter decreased under ambient storage conditions. The maximum TSS was recorded under $T_3$ treatment (1.5% $CaCl_2$) i.e. 13.36, 14.56, 14.89 and 13.95 °B at 3rd, 6th, 9th and 12th days of storage, respectively. While the minimum TSS was found in control during the all days of storage under ambient storage conditions. Treatments $CaCl_2$ @ 0.5 and 1.0 per cent proved significantly at par with treatment $T_3$ at 3rd, 6th and 9th days of storage, respectively. The increase of TSS in $T_3$ treatment was registered 45.94 per cent higher over control on 12th day of storage under ambient storage conditions.

The total soluble solid increased with duration of storage, reached its peak value after 9 days and 12 days under ambient storage conditions, and then starts in decreased manner during the storage conditions. This increase in total soluble solids was probably due to hydrolysis of polysaccharides and dehydration of fruits. Therefore, total soluble solids showed gradual decrease with the advancement of storage period which may be due to increase in senescence process and high respiration rate. The total soluble solids were found highest in the fruits treated with calcium chloride 1.5 percent, followed by calcium chloride 0.5 per cent under ambient conditions, respectively (Singh *et al*. 2010) [28]

Similar rise and fall in total soluble solids was also noticed in guava (Jayachandran *et al*. 2004) [32] and loquat (Akhtar *et al.* 2010). It could be probably because of delayed ripening, reduced respiration rate, lowered hydrolytic enzymes and metabolic activities. (Sakhale *et al*. 2009) [35]

**Titratable acidity (%)**

It is evident from the data presented in Table 3 that post-harvest treatments of Ber fruits with calcium chloride and SA treatments were decreased titratable acidity significantly during the storage period under ambient storage conditions up to 12th day. The maximum acidity *i.e.*0.253, 0.232, 0.221 and 0.171 per cent was recorded in $T_3$ (1.5% $CaCl_2$) while minimum *i.e.* 0.189, 0.159, 0.129 and 0.108 per cent under control at 3rd, 6th, 9th and 12th days of storage period under ambient storage conditions, respectively. The increased in titratable acidity in treatment $T_3$ was 58.33 per cent higher as compared to control 12th day of storage under ambient storage condition.

Titratable acidity showed a constant decreased with the post-harvest treatments of ber fruits by calcium chloride and SA during the storage period under ambient storage conditions. At all the storage intervals, $CaCl_2$ 1.5 per cent retained highest percentage of titratable acidity under ambient storage conditions and lowest was found in control. The declined in acidity may be attributed to utilization of acids in the process of respiration during ripening in presence of reduced supply of sugar as a substrate of respiration due to lower rate of starch degradation during ripening and which might be due to conversion of acids into salts and sugars by the enzymes particularly invertase. It could probably be due to delay in physiological ageing and alteration in metabolism. Gradual and progressive decrease in acidity was observed under all the treatments during storage and this progressive decline might be due to utilization of acid in metabolism. The reduction in acidity of Ber fruits was quite slow at cool temperature (Hiwale and Singh, 2003) [31]

**TSS / acid ratio**

A perusal of data in Table 4 indicated that significant variations recorded in TSS / acid ratio with post-harvest applications of calcium chloride and SA under ambient storage conditions. The minimum TSS / acid ratio *i.e.*52.81, 62.76, 67.38 and 81.58 at 3rd, 6th, 9th and 12th days was recorded in $T_3$ treatment (1.5% @ $CaCl_2$) than rest of the treatments under ambient storage conditions. While the maximum TSS/acid ratio was observed under control ($T_7$). However, the decreased in TSS / acid ratio with $T_3$ treatment was statistically at par with $T_6$ (60ppm $GA_3$) at 3rd day under ambient storage conditions. The application of $CaCl_2$ at the rate 1.5 per cent decreased the TSS / acid ratio of 18.33 per cent on 12th day of storage as compared to control.

The TSS / acid ratio increased with the advancement of storage period up to 12th day and 21st day under ambient storage conditions. The TSS / acid ratio of Ber fruits was significantly affected by calcium chloride 1.5 per cent under ambient storage conditions. The minimum TSS/acid ratio was observed with the calcium chloride 1.5 per cent which is superior over rest of the treatments under ambient storage conditions. Similar results were also obtained by Rajput *et al.* (2008) [33] in guava, Pathak *et al*. (2009) [34] in Aonla and Yadav and Varu (2013) in papaya.

**Total sugar**

It is apparent from the data table 4 revealed that different treatments of calcium chloride and SA significantly influenced the total sugar during ambient storage of Ber fruits. Application of 1.5 per cent $CaCl_2$ ($T_3$) recorded maximum total sugar content *i.e.*11.24, 12.32, 12.70 and 11.29 per cent at 3rd, 6th, 9th and 12th days of storage under ambient storage conditions, respectively. Further, this treatment was found significantly better among all the treatments except $CaCl_2$ 0.5 and 1.0 per cent at 3rd day and $CaCl_2$ 1.0 per cent at 6th day which was found statistically at par, respectively. It was also observed that total sugar content in Ber fruits were increased in all the treatments up to 9th day of storage under ambient storage conditions but decreased on 12th day of storage.

Total sugars increased initially with the highest on the 9th day of storage and declined this trend in all the treated fruits of Ber under ambient storage condition. The initial rise may be due to water loss from fruits through evapo-transpiration and inhibition of activities of enzymes responsible for degradation of sugars, while the subsequent decline may be due to utilization of sugars in respiration.

Fruits treated with calcium considering the effect of ripening retardants. The possible reasons and findings associated with increase in total sugar up to peak and slight decline with increase during storage period of total sugar which were with CaCl2 (1.5%) cause accumulation of sugar as a consequence of starch hydrolysis further at the over ripe stage the leaching of sugar was carried out because of hydrolysis process. Similar results was also recorded by Navdeep *et al*. (2005) in pear, Torres *et al*. (2009) [36] in atemoya and Girase (2011) in custard apple

**Reducing sugar (%) and non-reducing sugar (%)**

The data presented in Table 5 revealed that different treatments of calcium chloride and SA significantly influenced the reducing sugar under ambient storage condition. Treatment $T_3$ (1.5% $CaCl_2$) recorded maximum reducing sugar *i.e.* 6.39, 6.93, 7.08 and 6.19 per cent at 3rd, 6th, 9th and 12th days under ambient storage conditions, respectively. Further, this treatment was found significantly better among all the treatments which was found statistically at par over $CaCl_2$ 0.5 and 1.0 per cent at 3rd and 6th days and $CaCl_2$ 1.0 per cent at 9th day during storage period. The reducing sugar increased during storage time up to 9th day but decreased on 12th day of storage in all treatment combinations of Ber fruits. This treatment an increased 68.60 per cent more reducing sugar over control at 12th day under ambient storage conditions.

Reducing sugar content was continuously increased during the storage period under ambient storage conditions up to 9th day and 12th day, respectively peak than decline slightly in Ber fruits. This may be a consequence of release of sugar during starch hydrolysis. Ber is a non-climacteric fruit, rich in starch reserves and during post-harvest storage starch is hydrolyzed and liberating reducing sugars with enhancement of storage (Jayachandran *et al*. 2005 in guava and Navdeep *et al*. 2005 in pear) [37].

The non-reducing sugar was significantly affected with the application of calcium chloride and SA under ambient storage conditions. The non-reducing sugar increased during storage time up to 9th day but decreased on 12th day of storage in all treatment combinations of Ber fruits. The maximum non reducing sugar content in ber fruits *i.e.*4.85, 5.39, 5.55 and 4.85 per cent at 3rd, 6th, 9th and 12th days of storage was recorded under $T_3$ (1.5% CaCl2) during ambient storage conditions, respectively. However, the increase in non-reducing sugar CaCl2 @ 0.5 and 1.0 per cent at 3rd and 6th with $T_3$ treatment was statistically at par, respectively. The treatment 1.5 per cent CaCl2 was increased in non-reducing sugar to the extent of 75.17 per cent as compared to control.

Non-reducing sugars showed an increase up to 9th day of storage and decreased on 12th day of storage under ambient storage conditions. Initial increase in non-reducing sugars might be due to evapotranspiration losses and later decrease in non- reducing sugars might be due to conversion of these sugars into acids and also due to utilization of these sugars in respiration. The maximum non reducing sugar was retained in fruits treated with CaCl2 @ 1.5 per cent under ambient storage conditions, respectively. The present results are in close conformity with the finding of Agarwal and Jaiswal (2012) [38] in guava.

**Table 1:** Effect of post-harvest treatments on Physiological loss (%) and fruit spoilage of Ber during ambient condition

| Treatments | Physiological loss (%) | | | | Spoilage (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of days | | | | | | | |
| | 3rd | 6th | 9th | 12th | 3rd | 6th | 9th | 12th |
| $T_1$ | 7.83 | 12.26 | 20.58 | 32.48 | 2.50 | 11.50 | 19.00 | 45.50 |
| $T_2$ | 7.69 | 12.01 | 19.16 | 30.01 | 2.31 | 11.19 | 18.09 | 43.50 |
| $T_3$ | 7.21 | 11.79 | 18.01 | 28.78 | 2.11 | 10.98 | 17.17 | 40.10 |
| $T_4$ | 8.12 | 13.36 | 23.09 | 34.76 | 3.10 | 12.19 | 19.90 | 47.10 |
| $T_5$ | 7.99 | 13.01 | 22.21 | 32.96 | 2.90 | 11.97 | 18.50 | 44.20 |
| $T_6$ | 7.67 | 12.78 | 20.96 | 31.16 | 2.78 | 11.59 | 17.80 | 42.10 |
| $T_7$ | 10.14 | 17.89 | 25.01 | 41.10 | 4.73 | 18.10 | 28.30 | 59.20 |
| S. Em± | 0.16 | 0.15 | 0.29 | 0.60 | 0.04 | 0.21 | 0.32 | 0.56 |
| C.D @ 5% | 0.49 | 0.45 | 0.89 | 1.83 | 0.13 | 0.65 | 0.98 | 1.70 |

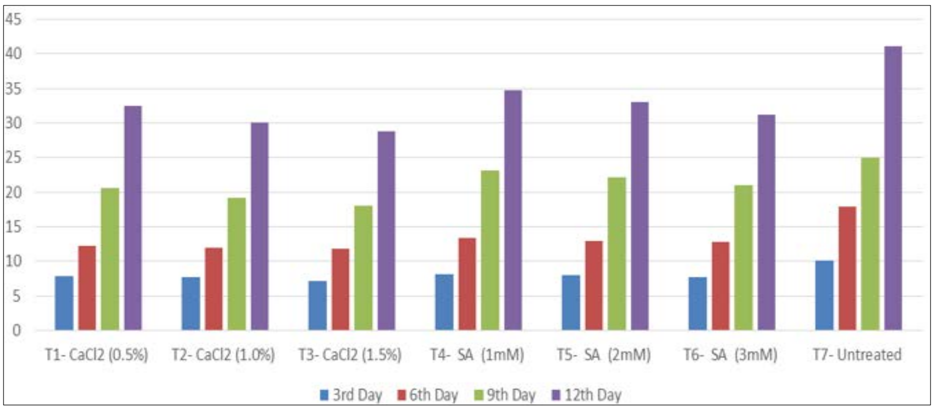


**Fig 1:** Effect of different post-harvest treatments on loss in weight of ber fruits

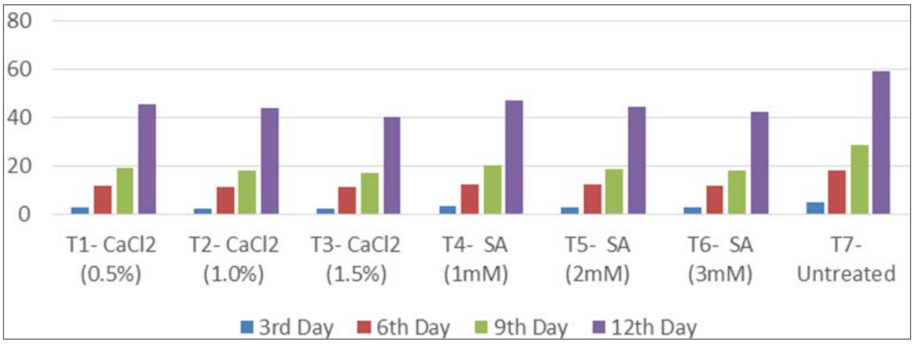


**Fig 2:** Effect of different post-harvest treatments on decay loss of ber fruits

**Table 2:** Effect of post-harvest treatments on Pulp stone ratio (%) Organoleptic sensory attributes of Ber during ambient condition

| Treatments | Pulp Stone Ratio | | | | Organoleptic Sensory Attributes | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of days | | | | | | | |
| | 3rd | 6th | 9th | 12th | 3rd | 6th | 9th | 12th |
| $T_1$ | 10.83 | 10.50 | 10.01 | 9.13 | 7.47 | 6.11 | 4.10 | 2.01 |
| $T_2$ | 11.43 | 11.02 | 10.65 | 9.77 | 7.77 | 6.41 | 4.31 | 2.22 |
| $T_3$ | 11.51 | 11.39 | 11.10 | 10.29 | 8.09 | 6.89 | 4.67 | 2.32 |
| $T_4$ | 10.62 | 10.06 | 9.49 | 8.64 | 7.10 | 5.74 | 3.96 | 1.81 |
| $T_5$ | 10.88 | 10.73 | 10.25 | 9.30 | 7.53 | 6.01 | 4.10 | 1.93 |
| $T_6$ | 11.06 | 11.00 | 10.60 | 9.62 | 7.98 | 6.39 | 4.32 | 2.09 |
| $T_7$ | 10.18 | 9.47 | 8.38 | 7.26 | 6.16 | 5.07 | 3.10 | 0.25 |
| S. Em± | 0.21 | 0.18 | 0.10 | 0.12 | 0.13 | 0.10 | 0.06 | 0.03 |
| C.D @ 5% | 0.64 | 0.56 | 0.29 | 0.38 | 0.39 | 0.30 | 0.18 | 0.09 |

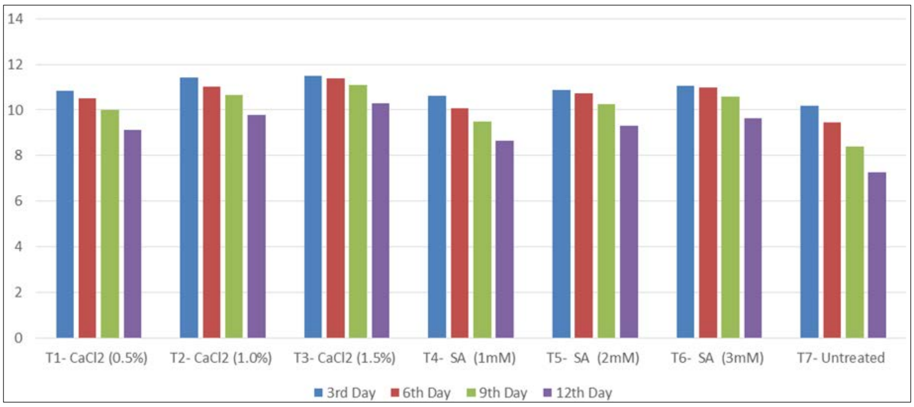


**Fig 3:** Effect of different post-harvest treatments on pulp / stone ratio of ber fruits

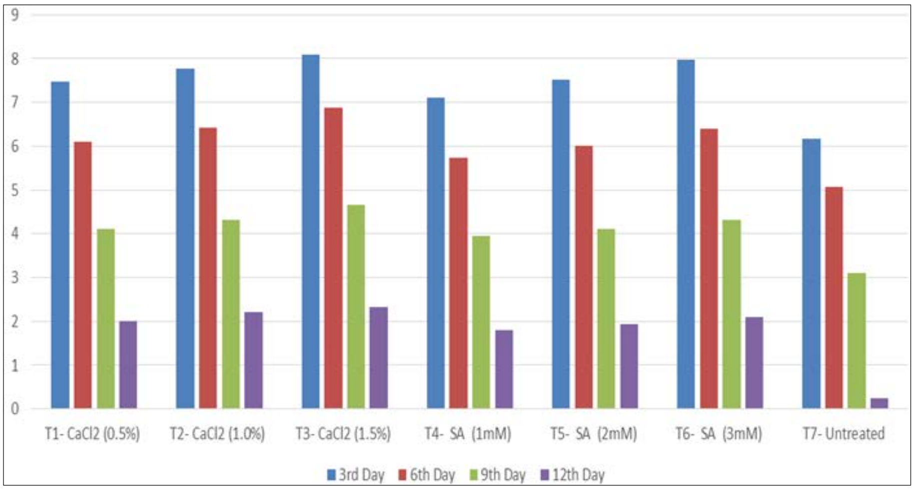


**Fig 4:** Effect of different post-harvest treatments on organoleptic rating of ber fruits

**Table 3:** Effect of post-harvest treatments on TSS (Brix %) and Titrable Acidity of Ber during ambient condition

| Treatments | Total soluble solid | | | | Titrable Acidity | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of days | | | | | | | |
| | 3rd | 6th | 9th | 12th | 3rd | 6th | 9th | 12th |
| $T_1$ | 13.20 | 14.37 | 14.71 | 13.11 | 0.224 | 0.201 | 0.184 | 0.141 |
| $T_2$ | 13.29 | 14.45 | 14.79 | 13.31 | 0.238 | 0.219 | 0.199 | 0.157 |
| $T_3$ | 13.36 | 14.56 | 14.89 | 13.85 | 0.253 | 0.232 | 0.221 | 0.171 |
| $T_4$ | 12.30 | 13.36 | 13.76 | 12.35 | 0.203 | 0.184 | 0.172 | 0.131 |
| $T_5$ | 12.36 | 13.43 | 13.84 | 12.53 | 0.219 | 0.199 | 0.180 | 0.139 |
| $T_6$ | 12.41 | 13.54 | 13.91 | 12.80 | 0.231 | 0.205 | 0.191 | 0.151 |
| $T_7$ | 12.11 | 12.34 | 12.50 | 11.49 | 0.189 | 0.159 | 0.135 | 0.108 |
| S.Em± | 0.18 | 0.19 | 0.13 | 0.21 | 0.004 | 0.003 | 0.003 | 0.002 |
| C.D @ 5% | 0.56 | 0.57 | 0.39 | 0.63 | 0.013 | 0.011 | 0.009 | 0.006 |

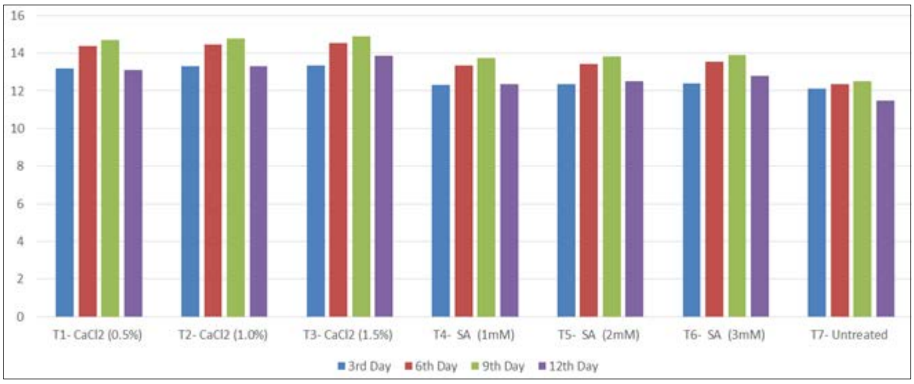


**Fig 5:** Effect of different post-harvest treatments on total soluble solids of ber fruits

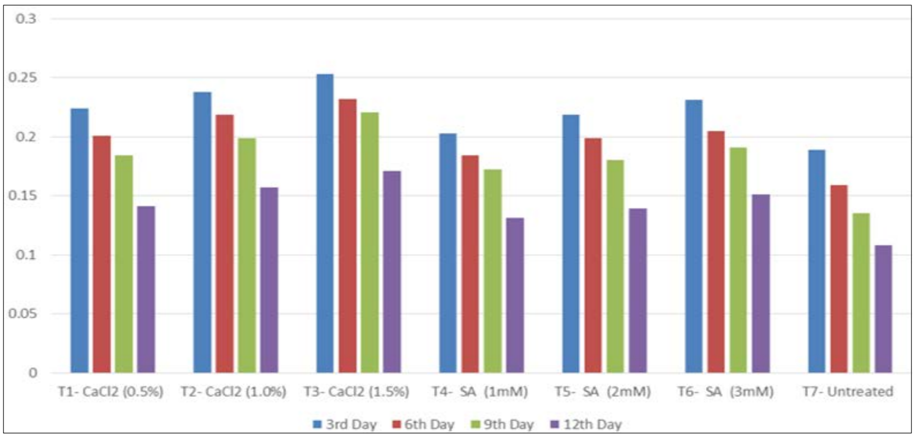


**Fig 6:** Effect of different post-harvest treatments on titratable acidity of ber fruits

**Table 4:** Effect of post-harvest treatments on TSS /Acid ratio and Total sugar of Ber during ambient condition

| Treatments | TSS/Acid Ratio | | | | | | | Total Sugar |
|---|---|---|---|---|---|---|---|---|
| | Number of days | | | | | | | |
| | 3rd | 6th | 9th | 12th | 3rd | 6th | 9th | 12th |
| T1-CaCl2 (0.5%) | 58.93 | 71.49 | 79.95 | 93.55 | 10.91 | 11.85 | 12.03 | 10.51 |
| T2-CaCl2 (1.0%) | 55.84 | 65.98 | 74.32 | 85.99 | 11.03 | 12.02 | 12.29 | 10.71 |
| T3-CaCl2 (1.5%) | 52.81 | 62.76 | 67.38 | 81.58 | 11.24 | 12.32 | 12.70 | 11.29 |
| T4-SA (1mm) | 60.59 | 72.61 | 80.00 | 94.27 | 9.45 | 10.08 | 10.55 | 9.14 |
| T5-SA (2mm) | 56.44 | 67.49 | 76.89 | 90.14 | 9.58 | 10.31 | 10.82 | 9.52 |
| T6-SA (3mm) | 53.72 | 66.05 | 72.83 | 88.90 | 9.73 | 10.59 | 11.13 | 9.93 |
| T7-Untreated | 64.07 | 77.61 | 85.74 | 99.89 | 9.29 | 9.83 | 8.53 | 7.23 |
| S.E(m) ± | 0.75 | 0.79 | 1.21 | 1.41 | 0.12 | 0.11 | 0.19 | 0.19 |
| C.D.(p=0.05) | 2.30 | 2.41 | 3.69 | 4.31 | 0.37 | 0.34 | 0.59 | 0.57 |

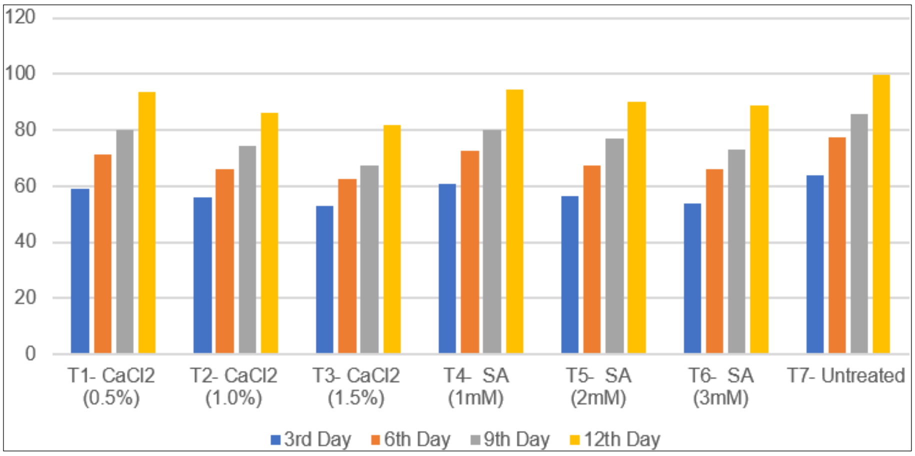


**Fig 7:** Effect of different post-harvest treatments on TSS / acid ratio of ber fruits

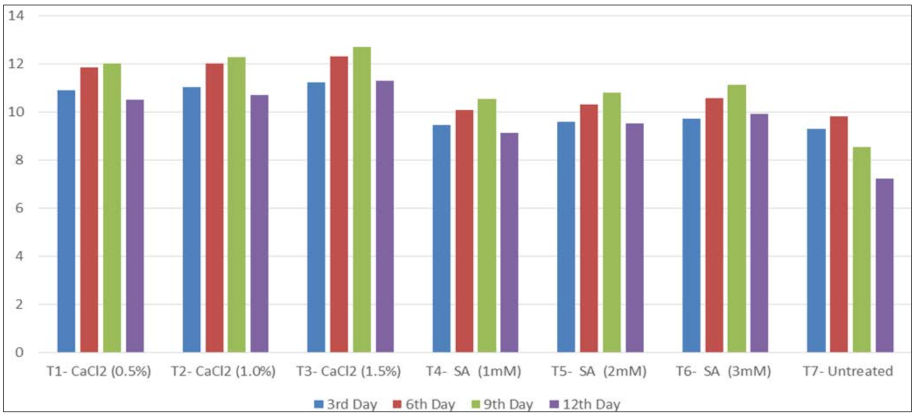


**Fig 8:** Effect of different post-harvest treatments on total sugar of ber fruits

**Table 5:** Effect of post-harvest treatments on Reducing sugar and non-Reducing sugar of Ber during ambient conditions

| Treatments | Reducing sugar (%) | | | | Non-Reducing Sugar (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of days | | | | | | | |
| | 3rd | 6th | 9th | 12th | 3rd | 6th | 9th | 12th |
| T1-CaCl2 (0.5%) | 6.24 | 6.74 | 6.80 | 5.80 | 4.67 | 5.11 | 5.23 | 4.45 |
| T2-CaCl2 (1.0%) | 6.29 | 6.81 | 6.89 | 5.88 | 4.74 | 5.21 | 5.31 | 4.62 |
| T3-CaCl2 (1.5%) | 6.39 | 6.93 | 7.08 | 6.19 | 4.85 | 5.39 | 5.55 | 4.85 |
| T4-SA(1mm) | 5.24 | 5.42 | 5.79 | 4.92 | 4.21 | 4.66 | 4.76 | 4.22 |
| T5-SA(2mm) | 5.29 | 5.56 | 5.99 | 5.21 | 4.29 | 4.75 | 4.83 | 4.31 |
| T6-SA(3mm) | 5.34 | 5.75 | 6.16 | 5.48 | 4.39 | 4.84 | 4.97 | 4.45 |
| T7-Untreated | 5.09 | 5.21 | 4.41 | 3.79 | 4.20 | 4.62 | 4.12 | 2.94 |
| S.E(m)± | 0.10 | 0.10 | 0.09 | 0.10 | 0.08 | 0.07 | 0.07 | 0.06 |
| C.D.(p = 0.05) | 0.31 | 0.31 | 0.27 | 0.30 | 0.24 | 0.23 | 0.21 | 0.20 |

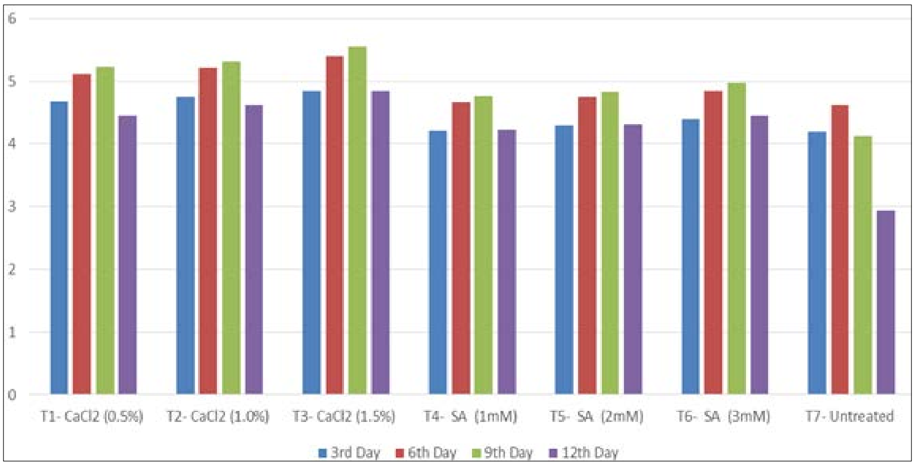


**Fig 9:** Effect of different post-harvest treatments on Non-reducing sugar of ber fruits

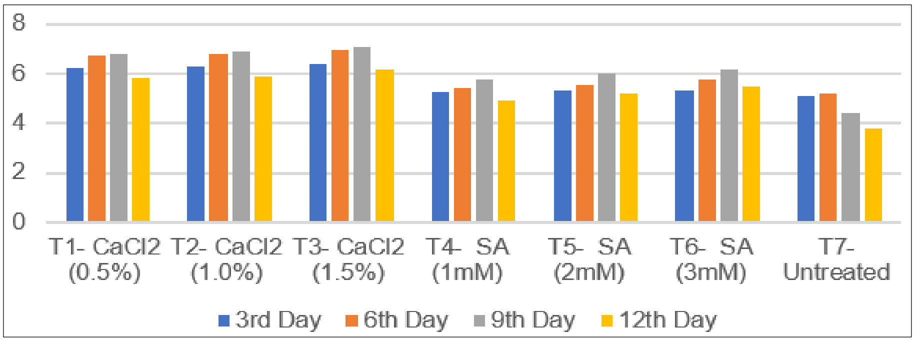


**Fig 10:** Effect of different post-harvest treatments on reducing sugar of ber fruits

**Conclusion**

On the basis of results obtained, it may be concluded that Ber fruits treated with 1.5 per cent calcium chloride as exogenous post-harvest treatment can be stored up to 9th day in ambient storage conditions without any applicable losses. Ber fruits were as good as fresh one like minimum PLW, decay loss with good marketability, palatability rating and appreciable bio chemical properties i.e., TSS, acidity and sugar.

It was concluded that the fruit growers and the fruit merchants in order to prolong the storage life of Ber fruits up to 9 days in ambient storage conditions. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion.

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