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Effect of calcium chloride postharvest treatment in combination with *Aloe vera* gel on fruit quality and storability of spine gourd (*Momordica dioica* Roxb.) fruits under refrigeration condition

R.L. Bhardwaj*, K. Choudhary, Kiran Hingoniya, Priyanka, Anita Sharma and Jaydeep Meena

*College of Agriculture, Sumerpur-Pali (Rajasthan)-306 902, India. *E-mail: rajubhardwaj3@gmail.com*

Abstract

An experiment was accomplished to examine the coating effect of calcium chloride ($CaCl_2$) and *Aloe vera* gel on postharvest shelf life and physico-chemical quality of highly perishable spine gourd (*Momordica dioica* Roxb.) fruits. Nine possible combinations of three levels of calcium chloride (10, 20 and 30%) and *Aloe vera* gel (10, 20 and 30%) were used for fruit coating in three replications. Fresh spine gourd fruits, which were treated with 30 percent of $CaCl_2$ and *A. vera* gel, showed significant ($P<0.05$) lower values of physiological loss in weight, fruit decay percent, colour development of fruits and total soluble solids. Conversely, fruit firmness, titratable acidity, organoleptic score, shelf-life duration and marketability were retained on the higher side in the same treatment. The marketability of the spine gourd fruits treated with $CaCl_2$ and *A. vera* gel at 30 percent was higher (85.63%) than those treated with the lower concentration and control. Therefore, observations suggested that by applying $CaCl_2$ and *A. vera* gel at 30 percent, the shelf-life of spine gourd fruit can be achieved up to 20 days with notable retention of the physico-chemical quality of fruits.

Key words: *Aloe vera* gel, coating, fruit firmness, physio-chemical properties, shelf-life

Introduction

Spine gourd (*Momordica dioica* Roxb.) belongs to the Cucurbitaceae and is an underutilized, most nutritious prehistoric vegetable crop (Bhardwaj *et al.*, 2024), distributed in tropical and sub-tropical parts of India, Pakistan, Bangladesh, Myanmar, China, Malaysia, Nepal, and Sri Lanka. It is widely consumed as a daily vegetable during the rainy season and an imperative source of nutritional as well as economic security for many tribals, who are living in undisturbed natural forest areas, especially at higher altitudes. It is extraordinarily nutritious (Salvi and Katewa, 2015; Jha *et al.,* 2017; Bhardwaj *et al.*, 2024).

Spine gourd fresh fruit availability is constrained by heavy postharvest loss (50-60%) due to short storage life, which ranges from 2-3 days under ambient conditions. The post-harvest deterioration rate of the spine gourd fruits is chiefly associated with its climacteric respiration rate and higher ethylene production during post-maturation stages. Large surface areas, protruding bristles, excessive seed development, weight loss, fruit decay, accelerated tissue softening, ripening of fruits with internal or external colour change and loss in fruit bitterness led to reduced shelf life and make marketing challenges. Edible coatings have been considered as an eco-friendly, non-toxic, cost-efficient and semi-permeable barrier to gases or water vapour from fruit surface which effectively enhances shelf life, through minimising weight loss, the release of bioactive compounds, enhancing the antioxidant activity, phenolic substances and leads to preserving the quality of fresh fruits during storage (Hernalsteens, 2020). Previous research utilized *Aloe vera* gel (Singh *et al.*, 2021), calcium lactate (Prajapati *et al.*, 2021), and calcium chloride (Sunila *et al.*, 2020) as a coating material to preserve fruit quality and enhance shelf life. It was previously confirmed by Gurjar *et al.* (2018), that the *Aloe vera* gel, Arabic gum, cactus mucilage and guar gum have been used to delay fruit ripening in tomatoes, extend the shelf life and inhibit fruit browning in guava, strawberry and apple. *Aloe vera* gel is a complex hydrophilic polysaccharide which acts as a transparent film around the fruit seals small wounds and stomata and creates an obstacle in transpiration, controlling respiratory rate, and maturation, hindering oxidative browning, which has a positive impact on extending shelf life, maintaining firmness and hindrance in fruit skin colour changes. It also contains various antibiotic and antifungal compounds that can inhibit microbial spoilage (Kator *et al.,* 2018). Calcium salt coating on various fresh fruits and vegetables is a proven technology to extend the shelf life by maintaining various physiological processes and textural attributes (Sunila *et al.*, 2020). Exogenous application of calcium chloride increases the calcium ionic (Ca^{2+}) concentration in the extracellular calcium pool, which improves the configuration of the cell wall by creating a bond with pectin, and keeps up the cell membrane stability, improving middle lamella rigidity and acting as a binding agent in the cell wall, which assists to conserve fruit firmness, minimizing the rate of fruit senescence and increases the storage life (Prajapati *et al.*, 2021). Several researchers have reported the advantages of calcium chloride ($CaCl_2$) in fresh fruit storage, but none of them used *Aloe vera* gel blend with calcium chloride as an edible coating to extend the storage life and maintain the quality of highly perishable, underutilized fresh spine gourd fruits.

The current work aimed to study the effect of *Aloe vera* gel and calcium chloride combinations to minimize postharvest losses of spine gourd fruits. The hypothesis behind this research is to develop an applicable way to extend the availability period and minimize postharvest losses of spine gourd fruits for the nutritional and economic security of tribals.

Materials and methods

Experimental material and site: Spine gourd (*Momordica dioica* Roxb.) fruits were harvested at the immature green stage from naturally grown creepers at Agricultural Research Substation, Sumerpur-Pali (Rajasthan) farm boundary and nearby tribal farmers fields in August 2023. Immediately after harvesting, all fruits were carefully transported to the Horticulture Laboratory. To remove field dirt and other inert material, fruits were rinsed with tap water and air dried. Only immature, well-developed fruits with uniform medium size, free from disease, injury, and bruises, were chosen for experimentation.

Preparation of coating solutions (*Aloe vera* gel and $CaCl_2$ solution): *Aloe vera* gel was extracted from full-grown, healthy and fleshy leaves by scientifically standardized method and put in sterilized clean glass bottles, and keep at 8 ºC for use. To obtain a 10%, 20% and 30% *Aloe vera* gel, 100 ml, 200 mL and 300 mL gel were blended with 900 ml, 800 mL and 700 mL of sterilized distilled water, respectively. Calcium chloride ($CaCl_2$) solution of 10%, 20% and 30% (w/v) was prepared by dissolving 100 g, 200 g and 300 g of edible grade $CaCl_2$ in each 1000 mL lukewarm distilled water containing 0.01% (v/v) Tween-20 as a surfactant.

Treatment application and experimental work: Selected spine gourd fruits were arbitrarily divided into ten treatment lots with three replications containing 500 g of fruits in each replicate. A group of 250 g of fruits for each treatment was used for weight loss and fruit decay percentage assessment. Double-coated postharvest fruit dipping treatments with all nine combinations were applied as10%, 20% and 30% $CaCl_2$ solutions for 5 minutes then, air-dried for 30 minutes at ambient temperature, followed by another dipping in 10%, 20% and 30% *Aloe vera* gel for 5 minutes and air-dried for 30 minutes at normal temperature. For control, three lots of uncoated fruits were kept after 5 minutes of dipping them in distilled water. Treated fruits were placed in 2 percent perforated polyethene film bags and stored in refrigeration at 10 ± 2 °C temperature with 85% ± 5 relative humidity for 20 days. The abbreviations and treatment combinations used in the study are as follows: T_1 represents the control group, while T_2 consists of 10% Aloe Vera and 10% $CaCl_2$. T_3 includes 10% Aloe Vera and 20% $CaCl_2$, and T_4 is made up of 10% Aloe Vera and 30% $CaCl_2$. T_5 combines 20% Aloe Vera with 10% $CaCl_2$, and T_6 features 20% Aloe Vera with 20% $CaCl_2$. T_7 contains 20% Aloe Vera and 30% $CaCl_2$, while T_8 consists of 30% Aloe Vera and 10% $CaCl_2$. T_9 combines 30% Aloe Vera with 20% $CaCl_2$, and T_{10} contains 30% Aloe Vera and 30% $CaCl_2$.

Postharvest fruit quality assessment: Fruit physico-chemical attributes, such as fruit weight, colour, total soluble solids, fruit firmness, and titratable acidity etc. were evaluated on the date of the experiment (zero-day) before treatments and at 10th, 15th and 20th days after storage. Three fruits were randomly selected from each replication per treatment used for assessment.

Physiological loss in weight (PLW%): The sample fruits were weighed on the 10th, 15th and 20th days after storage with the help of an electronic weighing balance and the difference in weight loss was stated in percentage on a fresh weight basis and was calculated using the following formula (Pila *et al.*, 2010)

$$\text{PLW}(\%) = \frac{\text{Initial fruits weight (g) - Weight after known storage period (g)}}{\text{Initial fruit weight (g)}} \times 100$$

Fruit decay percentage: Fruit decay was observed by visual observation/degree of infection, and data were articulated as the percentage of fruit showing particular signs of some disease/ rotting/fruit splitting or disorders such as ridge blackening, fungal growth, shrivelling, blackening and yellowing (Prajapati *et al.,* 2021) was observed, and the percent of decay was calculated for both treated and non-treated fruits using the following formula (Pila *et al.*, 2010):

$$\text{Fruit decay } (\%) = \frac{\text{Decay fruit weight after known storage period (g)}}{\text{Initial fruit weight (g)}} \times 100$$

Colour development in fruits: Colour development in fruits was determined by visual observation and weighing of yellow and reddish colour fruits, data were expressed as percentages.

$$\text{Fruit colour development } (\%) = \frac{\text{Yellow and reddish colour fruit weight after known storage period (g)}}{\text{Initial fruit weight (g)}} \times 100$$

Fruit firmness (N): A digital penetrometer device with a 6 mm steel tip head was used to compute the average force needed to puncture the fruit's flesh by randomly selecting three fruits from each group. The sample was compressed using a cylindrical probe by programmed settings for measuring the force in compression mode at speed (Pre-test: 5 mm second^{-1}, Test speed: 2 mm second^{-1}, Post-test speed: 10 mm second^{-1}, Distance: 20 mm). The maximum force the fruit could endure during the compression process was defined as the firmness of the fruit, expressed in N.

Total soluble solid (TSS): Fruit TSS was measured by hand refractometer (ATAGO TC-1E) with a range of 0 to 32 °Brix and resolutions of 0.2 °Brix by placing 1 to 2 drops of clear fruit juice on the prism, before using washed with distilled water and dried by tissue paper. The refractometer was standardized against distilled water (0°Brix) and the result was recorded as °Brix (Pila *et al.*, 2010).

Titratable acidity: Titratable acidity in spine gourd fruit juice samples was quantified by titration using 0.1 mol L^{-1} NaOH, and the endpoint was pH (8.1). 7.5 mL of spine gourd fruit juice was diluted with 42.5 mL of distilled water; 4 drops of phenolphthalein were added as an indicator, then titrated with 0.1 NaOH till the colour changed to light pink. The result was communicated as a citric acid percentage using the following formula:

$$\text{Acid } (\%) = \frac{\text{(Mls NaOH used) x (0.1 N NaOH) x (Milli-equivalent factor for spine gourd) -(100)}}{\text{Weight of sample (g)}}$$

Milli-equivalent factor = 0.0064 g

Organoleptic score: To determine the organoleptic score of the spine gourd fruits based on taste, aroma, pungency, bitterness, texture, and overall acceptability of fruits was done by semi-trained judges using ten-point hedonic scales (Amerine *et al.*, 1965). The hedonic scale ranged from 1.0 (very highly unacceptable) to 10.0 (very highly acceptable) which means a liking score of 7.01 or higher on a ten-point scale usually indicates a moderately acceptable organoleptic score; hence, a product achieving this score could be used with assurance as a good quality.

Shelf life of fruits (%): The number of days the spine gourd fruits remained consumption quality/palatable during the storage was recorded. The shelf life of fruits was calculated by using the following formula

$$\text{Shelf life(\%)} = \frac{\text{Palatable fruit weight after known storage period (g)}}{\text{Initial fruit weight (g)}} \times 100$$

Marketability (%): Marketability of fruits was recorded as the weight of healthy and marketable fruits during storage, based on expressive features such as intensity of observable lesions, shrinking, freshness, smoothness and green brightness of fruits. The marketability percent of stored fruits was estimated by the following formula.

$$\text{Marketability (\%)} = \frac{\text{Total marketable fruits after known storage period (g)}}{\text{Initial fruit weight (g)}} \times 100$$

Statistical analysis: The analysis of variance (ANOVA) was performed using the '*AOV*' function under the 'STATs' package in R. Tukey's HSD (honestly significant difference) was used for evaluating mean separation at 5% level of probability, using sigma plot (Version 8) in draw figure to show a significant difference.

Results and discussion

Physiological loss in weight (PLW): The experimental results shown in Fig. 1 that the combinations between higher levels of *Aloe vera* gel (30%) and $CaCl_2$ (20%) demonstrated minimum weight loss (10.73%) in T_9 followed by T_{10} treatment (11.05%) with a contrast in T_1 (26.86%) on 20^{th} days of storage. The key cause of fruit weight loss through storage is water loss by transpiration and utilization of reserve carbon due to fruit respiration. The hygroscopic properties of aloe gel allow the formation of a semi-permeable layer due to the occurrence of polysaccharides, which confines water losses. The results conform with earlier studies of Nourozi and Sayyari (2020) in apricots; Singh *et al.* (2021) in many fruits; Hassan *et al.* (2022) in strawberries; ValizadehKaji and Fakhri (2023) in duke cherry. Similarly, calcium ion furthermore plays a significant role in preserving fruit physiology by stabilizing the cell membrane, which could be attributed to enhanced membrane integrity, slower rate of respiration, transpiration, and maintaining the turgor pressure through interacting with pectic acid present in the cell wall of the spine gourd fruits. Close consequences were also reported by Sunila *et al.* (2020) in sweet oranges; Prajapati *et al.* (2021) in bitter gourd.

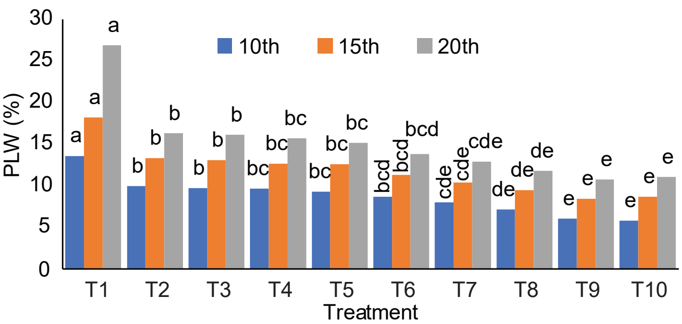

Fig. 1. Effect of *Aloe vera* gel and $CaCl_2$ on physiological loss in weight of spine gourd fruits during storage

Fruit decay percentage: The coating treatments significantly delayed the decay symptoms of spine gourd fruits up to 20 days of storage compared to non-treated fruits (Fig. 2). Among all treatments in T_1 (5.56%) and T_2 (3.03%), fruits decay begin from the 10^{th} days of storage. At 15 days, fruit decay initiated in all treatments and gradually augmented with the progression of the storage period, but at a minimum (10.67%) in fruits coated with *Aloe vera* gel (20%) in combination with $CaCl_2$ (30%), whereas maximum fruit decay (22.22%) was detected in control at end of storage**.** Treatment T_7 (10.67%), T_9 (10.95%) and T_{10} (10.75%) showed non-significant differences at the end of the experiment. This indicates that a higher concentration of coating substance *Aloe vera* gel and calcium chloride combined treatments effectively reduced its decay rate at later stages of storage in comparison to lower concentration coating and control fruits. *Aloe vera* gel inhibitory effects on postharvest pathogens growth can be due to anti-microbial potentiality by the presence of Aloe-emodin, aloenin, and other active compounds (Martinez-Romero *et al.*, 2017). The results of the present experiment agree with those obtained by Rasouli *et al.* (2019) in oranges; Singh *et al.* (2021) in many fruits; Hassan *et al.* (2022) in strawberries and Mani *et al.* (2022) in tomatoes. Calcium chloride plays a major role in strengthening and thickening the middle lamella of the cell wall, through the increased formation and deposition of Ca-pectate in the cell wall, it can efficiently reduce the occurrence of diseases, slow down ethylene production, delayed softening and ripening of fruit and vegetables (Hou *et al.*, 2021), which makes it difficult for pathogen to enter into the host tissue and hence maintaining its shelf life for longer duration. The current results agreed with Prajapati *et al.* (2021) in bitter gourd; Mazumder *et al.* (2021) in tomatoes.

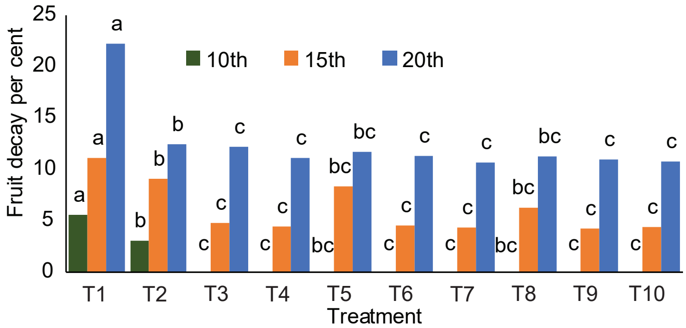

Fig. 2. Effect of *Aloe vera* gel and $CaCl_2$ on fruit decay (%) of spine gourd fruits during storage

Fruit colour development: Colour changes of spine gourd fruits during storage were observed from dark green to light green, yellow and bright red colour with successive storage periods. However, significant differences were found between control and *Aloe vera* gel and $CaCl_2$-treated fruits (Fig. 3). Among different treatments, T_9 was found effective in maintaining the natural green colour with minimum colour changes (13.76%), followed by T_{10} treatment (14.38%) and T_6 (15.48%), whereas significantly higher colour change was reported in T_1 treatment (33.30%) at the end of storage period (20^{th} days). Both the coating substances

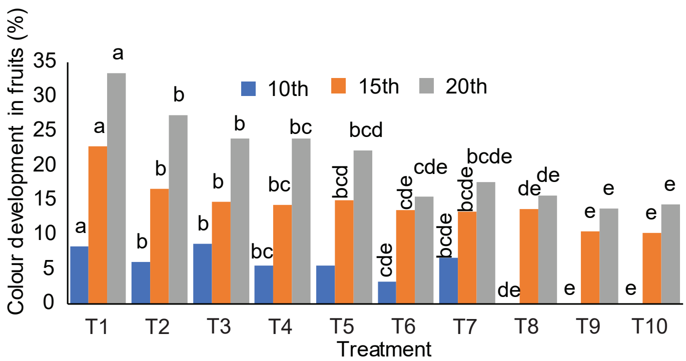

Fig. 3. Effect of *Aloe vera* gel and $CaCl_2$ on fruit colour development in spine gourd during storage

were found to delay chlorophyll degradation and anthocyanin accumulation or carotenoid synthesis, as well as retarded the ethylene production rate, therefore delaying ripening processes compared to uncoated fruits. Similar results were also reported that calcium chloride delayed colour in strawberries (Singh *et al.*, 2021). Previous studies demonstrated retardation of fruit colour changes one of the typical effects of *Aloe vera* gel coating, such as lime (Pimsorn *et al.*, 2022).

Fruit firmness (N): The current results indicated that the fruits coated with a higher concentration of *Aloe vera* gel in addition to $CaCl_2$ showed a positive significant (P<0.05) outcome on fruit firmness (Fig. 4). Among storage days mean, the highest firmness (42.70N) was recorded at the initial day and the lowest (16.37N) on the 20th day of storage in untreated fruits. Treatment means also signifies the higher retention of firmness in fruit treated with *Aloe vera* gel and $CaCl_2$ (27.88N) compared to control (16.37N). Throughout the storage period, the T_8 treatment (31.13N), T_7 treatment (30.97N), and T_9 treatment (30.63N) consistently demonstrated significantly higher fruit firmness than all other treatments and control (16.37N). These changes are attributed to deterioration in cell structure, cell wall composition and intracellular components during the ripening process at storage as has been reported for a wide range of fruits, including tomatoes (Ruelas-Chacon *et al.*, 2017). Postharvest application of calcium chloride inhibited cell wall activity, degrading enzymes, so the cell wall's outer membrane became more strong and rigid. *Aloe vera* gel in-combination treatments also helped to elevate the CO_2, which decreased the fruit respiration rate, therefore limiting the activity of softening-related biochemical enzymes such as; hydrolases, pectin esterase, and poly-galacturonase (Ruelas-Chacon *et al.*, 2017). A decline in the firmness of cherries throughout the storage has been observed by Hu and Feng (2022), which could be associated with the activity of cell wall degrading enzymes, dehydration due to water loss, and pathogen infection (Saki *et al.*, 2019). Furthermore, similar findings on the positive effects of *Aloe vera* gel and $CaCl_2$ on fruit firmness have been obtained in plums (Martinez-Romero *et al.*, 2017); tomatoes (Mazumder *et al.*, 2021); strawberries (Hassan *et al.*, 2022), and duke cherry (ValizadehKaji and Fakhri, 2023).

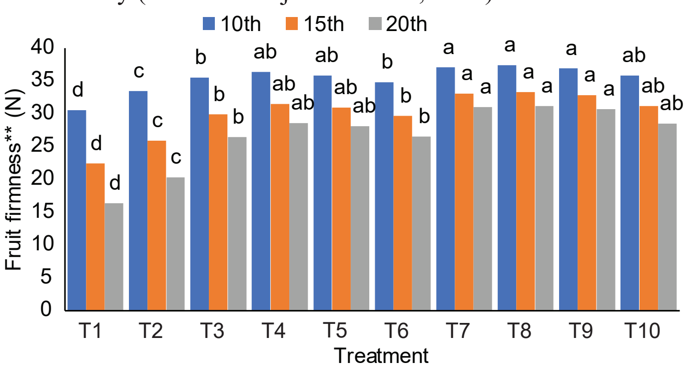

Fig. 4. Effect of *Aloe vera* gel and $CaCl_2$ on firmness in spine gourd fruits during storage

Total soluble solids (°Brix): The TSS content of fruits before storage was about 2.5 °Brix and increased to 5.27 °Brix, 6.58 °Brix and 7.58 °Brix after 10, 15 and 20 days of storage in untreated fruits (Fig. 5). Throughout storage, both the control and the coating groups exhibited an increasing trend in TSS throughout storage, which can be attributed to fruit dehydration, ripening and additionally, the breakdown of polysaccharide substances such as starch, pectin, and cellulose into soluble sugars. At the finish of storage, the highest physiological loss in weight (26.86%) was experienced in untreated fruits, whereas T_9 and T_7 had lower rates of 10.73% and 11.05%, respectively, resulting in corresponding TSS values of 7.58%, 4.34%, and 4.76%, respectively. There is no significant difference (P<0.05) observed between control (T_1) fruits and different postharvest coating treatments (T_2 to T_{10}) from zero days to until 10th days of storage (Fig. 5). While, on the 15th days of storage up to the termination day of the experiments (20th days), a significant difference in the total soluble solid was observed in non-treated fruits (7.58 °Brix) compared to 20 percent $CaCl_2$ treatments in-combination with 30 percent *Aloe vera* gel. A comparable to the accessed TSS alter pattern was also determined in oranges, which are treated with 30 percent *Aloe vera* gel (Rasouli *et al.*, 2019), as well as mandarin treated with 60 percent *Aloe vera* gel (Rashid *et al.*, 2020). Calcium chloride maintains TSS, it may be because of the calcium inhibitory effect that is responsible for turgor pressure failure and build-up membrane integrity (Sunila *et al.*, 2020). Comparable effects were also reported by Parjapati *et al.* (2021) in bitter gourd and Mazumder *et al.* (2021) in tomatoes.

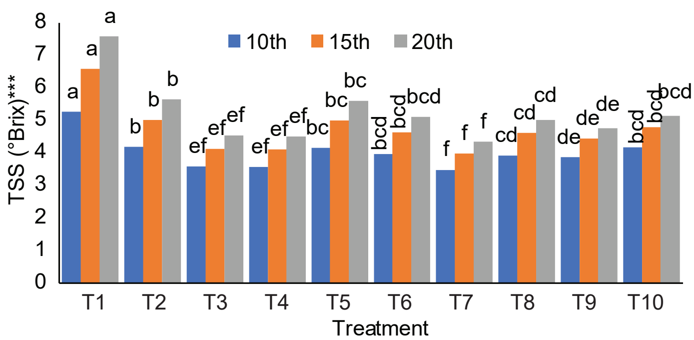

Fig. 5. Effect of *Aloe vera* gel and $CaCl_2$ on TSS in spine gourd fruits during storage

Titratable acidity: Titratable acidity significantly decreased with the advancement of the storage period, which was observed in all the treatments, including control fruits, and the decline rate was fastest in control and slowest in the T_{10} treatment (Fig. 6). At the end of storage, the highest titrable acidity (2.92%) was found in T_{10} treatment, which was followed by T_9 treatment (2.81%) and T_7 treatment (2.80%), whereas the lowest (0.23%) was reported in control (Fig. 6). The decreased acidity during storage might be due to the metabolic changes in fruits resulting from the use of organic acids in the respiratory process; this observation was in harmony with the findings of Sunila *et al.* (2020) in sweet orange. A decrease in titratable acidity of fruits during the storage has been explained for strawberries (Hassan *et al.*, 2022); mangos (Khalil *et al.*, 2022), which could be due to the rise in respiration

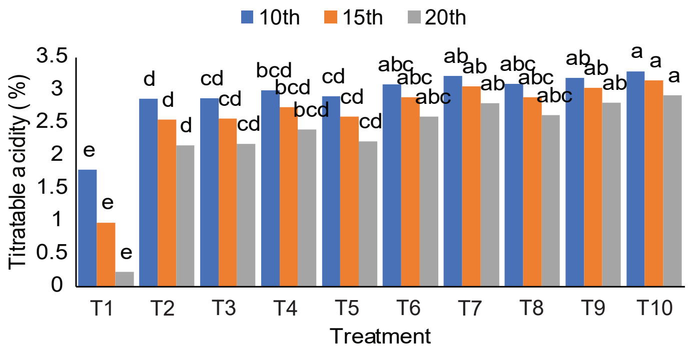

Fig. 6. Effect of *Aloe vera* gel and $CaCl_2$ on acidity in spine gourd fruits during storage

rate and utilization of organic acids, water losses, breakdown of glycoside into sub-units, and the catabolism of polysaccharides into simple sugars (ValizadehKaji *et al.*, 2023). Furthermore, the positive effects of *Aloe vera* gel have been reported for strawberries (Hassan *et al.*, 2022) and duke cherry (ValizadehKaji and Fakhri, 2023) which is consistent with experimental findings.

Organoleptic score: The statistical outcomes of the data revealed that both the coating application had a potential (P<0.05) impact on the organoleptic score of spine gourd fruits up to 20 days (Fig. 7). The organoleptic score of spine gourd fruits showed that during the initial days of storage, the treated and control fruits significantly differed due to more bitterness and astringency of higher concentration (30%) of *Aloe vera* gel and $CaCl_2$. From treatments, the highest mean value was observed in T_4 (8.0; moderately acceptable) followed by T_3 (7.95; moderately acceptable), while the minimum score was noted in T_1 (6.0; neither acceptable nor unacceptable) followed by T_8 and T_9 (6.25; slightly acceptable). Before the application of treatments, fruits were very high and acceptable for consumption but at the end of the study period, fruits in T_1 treatment were neither acceptable nor unacceptable (6.0) due to their poor organoleptic score. The reason behind the higher retention organoleptic score in *Aloe vera* gel and calcium chloride treated fruit could be due to the activation of the biosynthetic pathway responsible for the accumulation of phenols and other active substances; those are accountable for upholding good taste in addition to an organoleptic score of the stored fruits. Earlier research has shown that calcium might perform as a potential molecule for triggering the phenylpropanoid-flavonoid pathway of fruit by escalating the activity of PAL, which leads to more accumulation of phenols. Analogous results were also observed with calcium chloride coating by Sunila *et al.* (2020) in sweet oranges; Singh *et al.* (2021) in different fruits; Prajapati *et al.* (2021) in bitter gourd fruit and Hazarika *et al.* (2021) in different fruits.

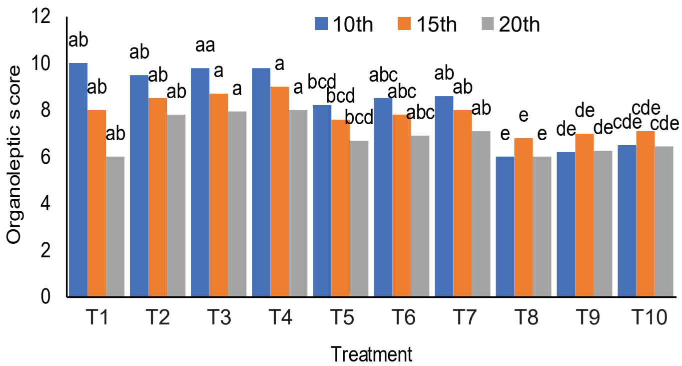

Fig. 7. Effect of *Aloe vera* gel and $CaCl_2$ on organoleptic score of spine gourd fruits during storage

Shelf life of the fruits: The *Aloe vera* gel and $CaCl_2$ coatings had a statistically considerable effect on the post-harvest life of the spine gourd fruits after 10 days of storage (Fig. 8). Fruits were treated with a higher concentration of *Aloe vera* gel and $CaCl_2$ under treatment T_9 (89.57%) and T_{10} (89.35%) showed the highest fruits shelf life up to 20th days of storage, which was significantly greater than the other treatments, whereas untreated fruits had the minimum shelf life (71.92%). Moreover, *Aloe vera* gel and $CaCl_2$ treatments have been found to delay ripening and extend storage life, through modified atmospheres such as high CO_2 and low O_2, which help in delay senescence and ripening by reducing respiration and ethylene production rate in climacteric fruits such as tomato (Pila *et al.*, 2010). The maximum shelf life of fruits with coatings, of *Aloe vera* gel, $CaCl_2$, and their combination have been reported for fig (Saki *et al.*, 2019); strawberry (Hassan *et al.*, 2022); cauliflowers (Mu *et al.*, 2022); sweet cherry (Mujtaba *et al.*, 2023) and duke cherries (ValizadehKaji and Fakhri, 2023) which is in agreement with experimental findings.

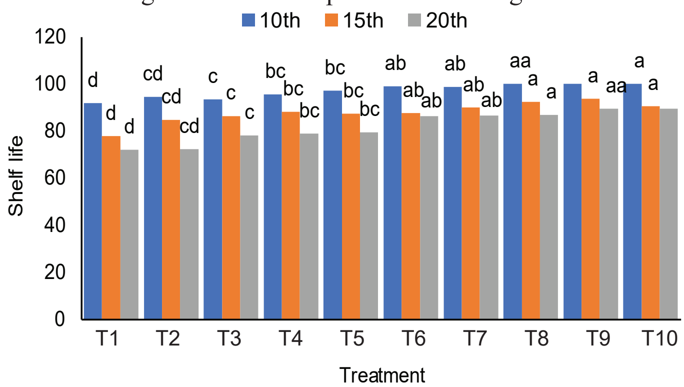

Fig. 8. Effect of *Aloe vera* gel and $CaCl_2$ on shelf life of spine gourd fruits during storage

Marketability of fruits: The edible coatings of *Aloe vera* gel and $CaCl_2$ had a statistically non-significant effect on the marketability of spine gourd fruits on the 10th day of storage, but after that, treated fruits had considerably higher marketability than non-treated ones (Fig. 9). The highest marketability of the fruits was reported in T_{10} treatment (85.63%), which was closely followed by the T_6 (84.52%), T_8 (84.38%), T_9 (86.24%) treatments, whereas the lowest marketability of the fruits (66.67%) was observed in control on 20th days of storage. As a divalent cation nutrient element, calcium ions (Ca^{2+}) have significant role in delaying ageing and improving antioxidant capability in the cell wall and membrane structure due to cross-linking process between Ca^{2+} and carboxyl groups in pectin, which helps to increase the strength of the cell wall and retain fruit firmness and tissue structure (Nguyen *et al.*, 2020). Aloe vera gel fruit coatings have been shown to prevent moisture loss, maintain fruit firmness, manage respiratory speed and maturation progress, delay oxidative browning, and significantly reduce microorganism infestation in stored fruits (Hazarika *et al.*, 2021). Increased marketability in tomato fruits, as experiential in this study, is in line with the findings of Marpudi *et al.* (2011), who observed that without coating have the least marketability while coated fruits have the maximum in tomato. A similar observation was made by Kator *et al.* (2018).

Post-harvest application of *Aloe vera* gel and calcium chloride

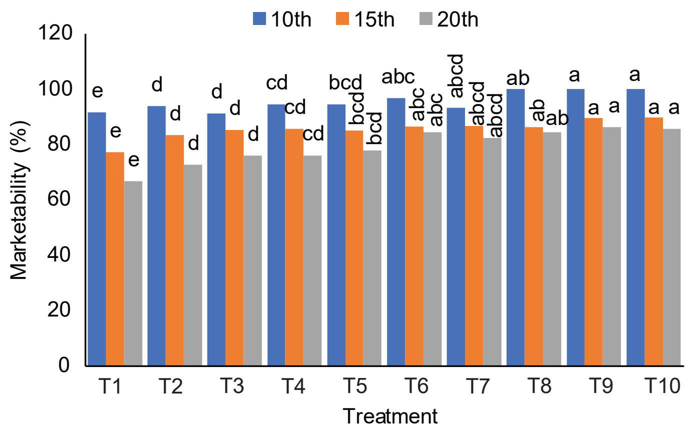

Fig. 9. Effect of *Aloe vera* gel and $CaCl_2$ on marketability of of spine gourd fruits during storage

as fruit coating significantly lowered values of physiological loss in fruit weight, delayed in fruit decay, maintained fruits natural green colour, fruit firmness, and sustains total soluble solids, titratable acidity and organoleptic score of the fruits during storage. Furthermore, a higher concentration of *Aloe vera* gel (30%) with $CaCl_2$-treated fruits has a longer shelf life and higher marketability up to 20 days of storage. Therefore, applying *Aloe vera* gel with calcium chloride to prolong the storage life of spine gourd fruits has revealed vast realistic potential. This blended treatment has a range of advantages, including being natural, beneficial to health, edible, and competent. Despite considerable findings of the current research, further work needs to be done on a combination of other natural coating products and essential minerals to safeguard the quality of underutilized nutritious spine gourd fruits.

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