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IMPROVING THE SHELF LIFE OF JACKFRUIT BULBS BY OPTIMIZING DIFFERENT PRETREATMENTS DURING STORAGE

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ABSTRACT

To extend the shelf life of harvested jackfruit bulbs, the bulbs were pre-treated with different concentrations of calcium chloride ($CaCl_2$), ascorbic acid (AA) and potassium metabisulphite (KMS), packed in stand-up pouches and stored at 4°C. The study was conducted at university of horticultural sciences, Bagalkot for one year. The design of study was completely randomised block design. In the pretreated bulbs, T_9 (1.5% $CaCl_2$ + 0.5% AA +100 PPM KMS) recorded lowest total soluble solids (29.16°Brix), maximum titratable acidity (0.442%), maximum *L** value (43.03), maximum *b** value (41.81), maximum texture (31.78 N), lowest physiological loss of weight (3.77%), minimum microbial count of yeast and bacteria (2.95 and 2.84 log cfu/g) and maximum score for overall acceptability (7.85). Among treatments, T_9 was found with highest shelf life of 16 days. Therefore, among different treatments, it is found that treatment (T_9) with 1.5% $CaCl_2$+ 0.5% AA + 100 ppm KMS revealed extended shelf life upto 16 days.

Key words : Preservation, Calcium chloride, Ascorbic acid, Jackfruit bulbs, Shelf life, Microbial load.

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) is a tropical fruit native to India, Bangladesh, Sri Lanka, southern China and Southeast Asian countries, with limited production in Australia, Mauritius, Brazil, Surinam, Jamaica, Mexico, Hawaii, and southern Florida. It is mostly used as a starchy vegetable for curry preparation when unripe and as a dessert fruit when ripe. Jackfruit is also frequently used in Ayurvedic and Yunani medicinal preparations (Mukherjee, 1993). As such, the edible delicious ripe jackfruit bulbs have an appealing golden yellow colour and flavour. Firm jackfruit bulbs remain firm even when fully ripe, whereas soft jackfruit bulbs become pulpy and soft when ripe (Rahman *et al.*, 1999). Because the edible fleshy pericarp accounts for only 35% of the whole fruit and is prone to flavour loss, tissue softening, cut-surface browning and post-harvest decay (Narasimham, 1990), it is important to develop appropriate processing and storage protocols for pitted and pre-cut bulbs. Pre-cut jackfruit bulbs can be made convenient for consumers and appropriate post-harvest technology for shelf-life extension may facilitate transportation from the production site to a remote location. The post harvest dip pre-treatment of chemical preservatives such as calcium chloride, ascorbic acid, potassium metabisulphite, at minimum levels alone or in combination during minimal processing have been found to be beneficial in minimizing the stress-induced metabolism, maintaining firmness, reducing browning reaction and improving organoleptic quality of various produce along with extension of their shelf-life (Soliva *et al.*, 2002; Martinez-Ferrer *et al.*, 2002).

As calcium has been associated in the maintenance of texture in various fruits, its inclusion in the bulbs is expected to retain the crispness of the jackfruit. Ascorbic acid is the principal biologically active form but L-dehydroascorbic acid (DHA), an oxidation product, also exhibits biological activity. Potassium metabisulphite is a colourless free flowing crystal, crystalline powder or granules, usually having an odour of sulfur dioxide. Its functional properties are antibrowning agent, antioxidant and preservative.

On the other hand, demand for jackfruit has been increasing owing to the popularization and other promotional activities by academic and research institutes, creating interest among the people across the country. In view of this, there is an urgent need for the technological intervention for developing suitable maturity indices that would meet the needs of growers.

Materials and Methods

Treatment details

The experiment aims to evaluate the effects of various treatments on jackfruit bulbs, with the bulbs packaged in stand-up pouches. The design includes 9 different treatments, each replicated 3 times, with a sample size of 5 bulbs per replication. The treatments involve varying combinations of calcium chloride, ascorbic acid and potassium metabisulphite. Specifically, T_1 uses 1% calcium chloride, while T_2 increases the concentration to 1.5%. T_3 applies 100 ppm potassium metabisulphite. T_4 and T_5 combine 1% and 1.5% calcium chloride, respectively, with 0.5% ascorbic acid. T_6 and T_7 incorporate 1% and 1.5% calcium chloride, respectively, with 100 ppm potassium metabisulphite. Finally, T_8 and T_9 involve a combination of calcium chloride (1% and 1.5%), 0.5% ascorbic acid and 100 ppm potassium metabisulphite. The study uses these treatments to assess the effects on the jackfruit bulbs. The process of giving pretreatments to jackfruit bulbs involved the following steps: Whole fruit was cut into half vertically. The bulbs as samples material were removed from fruits. Bulbs which are uniform in size, free from any infection pest or disease as well as physical damage were selected for further treatment. The bulbs were dipped to different concentrations of $CaCl_2$, Ascorbic acid and KMS for 5 minutes at ambient temperature. After treatments, the bulbs were air dried and placed in stand-up pouches with proper sealing and stored at 4°C.

Observations recorded

Total Soluble Solids (TSS) (°Brix)

Total soluble solid was determined by digital refractometer. The refractometer was first calibrated by using distilled water on the prism in the specimen chamber of the refractometer with the help of glass rod. For determining the TSS, the bulb was crushed in pestle and mortar and it was pressed in muslin cloth to get a juice. A drop of juice was placed on the prism and it was read directly. TSS was recorded and expressed in °brix at 30 days interval.

Titratable acidity (%)

A known quantity of sample was titrated against 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator (A.O.A.C., 1975). In case of jackfruit carpels, a known quantity or sample was blended in pestle and mortar with 20-25 ml distilled water. It was then transferred to 100 ml volumetric flask and filtered. A known volume of aliquot was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The results were expressed as per cent anhydrous citric acid at 30 days interval.

$$\text{TA (\%)} = \frac{\text{Titer value} \times \text{Normality of alkali} \times \text{Volume made up} \times \text{Meq. wt. of acid*} \times 100}{\text{Vol. of sample taken for estimation} \times \text{wt. or volume of sample} \times 1000}$$

*Note: Meq = milliequivalent

Meq wt. of citric acid = 0.06404

Colour (L*, a*, b*)

Colour of the samples was measured using Colour Flex EZ colorimeter (Model: CFEZ 1919, Hunter associate's Laboratory. Inc., Reston) fitted with 45 mm diameter aperture. The instrument was calibrated using black and white tiles provided. Colour was expressed in terms of *L** (lightness/darkness), *a** (redness/greenness) and *b** (yellowness/blueness). Three measurements were performed per sample at different parts of the fruit surface and values of the samples were averaged at two days interval.

Physiological loss of weight (%)

Bulbs from each treatment were taken to record the physiological loss in weight (PLW). The weight of the bulbs was recorded using precision electronic weighing balance (Model: Sartorius Weighing technology GmbH, Gottingen, Germany, GE812) before storage as initial weight .on subsequent dates of observation during storage ,the bulbs were weighed and recorded as final weight on every two days and the cumulative PLW was calculated with the following formula and expressed as per cent physiological loss in weight

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight - Final weight} \times 100}{\text{Initial weight}}$$

Texture (N)

Texture of pretreated bulbs was determined with TAXT plus Texture Analyzer (Make: Stable Micro System, Model: Texture Export Version 1.22). The force with the sample gets cut was recorded in the graph and the peak force value in the graph was taken as the texture value in terms of Newton force (N). The following instrument settings were used during the experiment:

Type of probe used	:	Blade set
Test option	:	Return to start
Test speed	:	1.0mm/s
Post-test speed	:	10.0 mm/s
Distance	:	25 mm
Load cell	:	1 bulb

Microbial count (log cfu/g)

The pretreated jackfruit bulbs were subjected to microbial analysis by employing serial Dilution method (David and Davidson, 2014). For enumeration of bacterial counts, a 10g sample of jackfruit bulbs was weighed aseptically and was diluted in 100 ml sterile water and subsequent dilutions were prepared up to 10^{-3} by transferring 1ml aliquot from 10^{-1} to 9 ml water blank. The filtrates serially diluted to 10^{-1}, 10^{-2}, 10^{-3} were used for enumerating bacteria and yeast population by plating on suitable media. The culture media used were Nutrient Agar and Yeast Extract Agar for total counts of bacteria and yeast respectively. Required dilution of 1ml was transferred to sterilized Petri plates and 15-20 ml of cultured media was poured to it. The plates were shaken in anticlockwise direction to attain uniform distribution of dilution to the culture media. The plates were then allowed to solidify the media and incubated for 3-5 days at 26 ± 2°C. The plates were then observed for bacteria and yeast colonies. The total colonies were counted and results expressed as colony forming units (log cfu/g of sample) were determined using the following formula:

$$\text{Total counts, log cfu/g} = \frac{\text{No. of colonies} \times \text{Dilution factor}}{\text{Weight of sample (g)}}$$

Sensory evaluation (9 hedonic rating scales)

Sensory evaluation of pretreated jackfruit bulbs was carried out by a semi-trained panel consisting of Teachers and Post-Graduate students of College of Horticulture, Bagalkot with the help of nine point hedonic rating scale (1 = dislike extremely, 2 = like only slightly, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely) Sensory parameters considered in evaluation included colour and appearance, texture, taste and flavour and overall acceptability.

Shelf life of jackfruit bulbs (days)

The shelf life of jackfruit bulbs was decided based on the overall acceptability of bulbs. When the bulbs attained beyond the edible ripe stage, then those bulbs were considered to have reached the end of their shelf life and expressed in days.

Data was analyzed by completely randomized design (CRD) statistical analyses of experiments were performed using Web Agri Stat Package (WASP) Version 2 (Jangam and Thali, 2010). The level of significance used in 'F' and 't' was p = 0.05. Critical difference values were calculated whenever F-test was found significant.

Results and Discussion

Total soluble solids (TSS) (°Brix)

The total soluble solids (TSS) (Fig. 1) in pretreated jackfruit bulbs increased from 23.24°Brix to 35.63°Brix during storage, with no significant differences observed between treatments. Under refrigeration (4°C), the lowest TSS was found in treatment T_9 (29.16°Brix), followed by T_8 (29.48°Brix) and the highest in T_3 (30.08°Brix), indicating T_9 as the best treatment. The increase in TSS is linked to fruit ripening and enzymatic conversion of starch to sugar. Pretreatments delayed ripening and senescence. Chulaki *et al.* (2017) showed that ascorbic acid, calcium chloride and citric acid treatments extended jackfruit bulb storage life, while Prathiba *et al.* (2018) found $CaCl_2$ and ascorbic acid improved shelf life and quality retention for up to 3 weeks.

Titratable acidity (%)

The titratable acidity (TA) (Fig. 2) of pretreated jackfruit bulbs decreased during storage from 0.566% to 0.137%, with significant differences observed between treatments. Under refrigeration (4°C), the highest TA was found in treatment T_9 (0.442%), followed by T_8 (0.433%) and the lowest in T_3 (0.358%), indicating T_9 as the best treatment. The decrease in acidity, linked to starch degradation into sugars, contributed to increased sweetness. Afrin *et al.* (2016) found that treatment T_3 (0.6% ascorbic acid) provided the best shelf life (12 days) and quality retention. Chulaki *et al.* (2017) attributed the decrease in acidity during storage to the respiration process. Similar results were found in guava and pear using calcium chloride treatments. Sakimin *et al.* (2017) highlighted that TA in minimally processed jackfruit increased during storage, with ascorbic acid losses due to oxidation.

Effect of different pre treatments on colour values (L*, a* and b*)

The L*, a*, and b* color values of jackfruit bulbs (Figs. 3, 4, 5), influenced by pretreatments, showed significant differences for L* and b* values. L* indicates lightness, while b* measures yellowness, both critical for

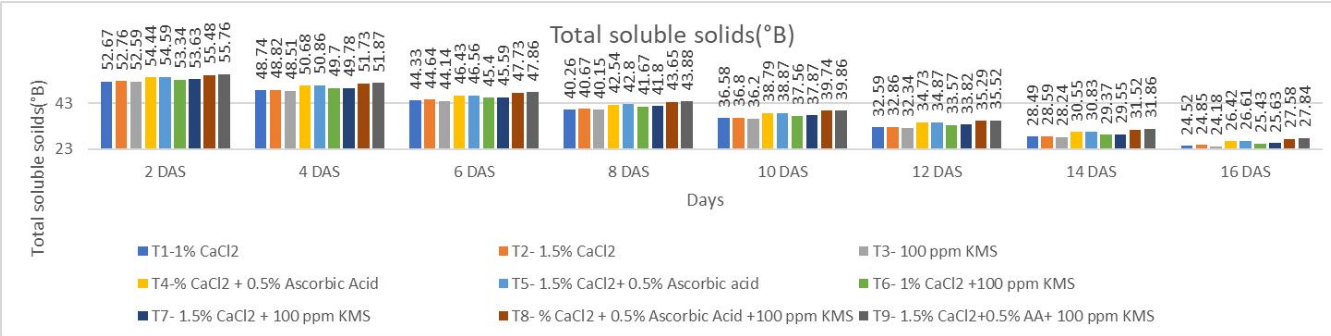

Fig. 1 : Effect of pre-treatments on total soluble solids (TSS) (°Brix) of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

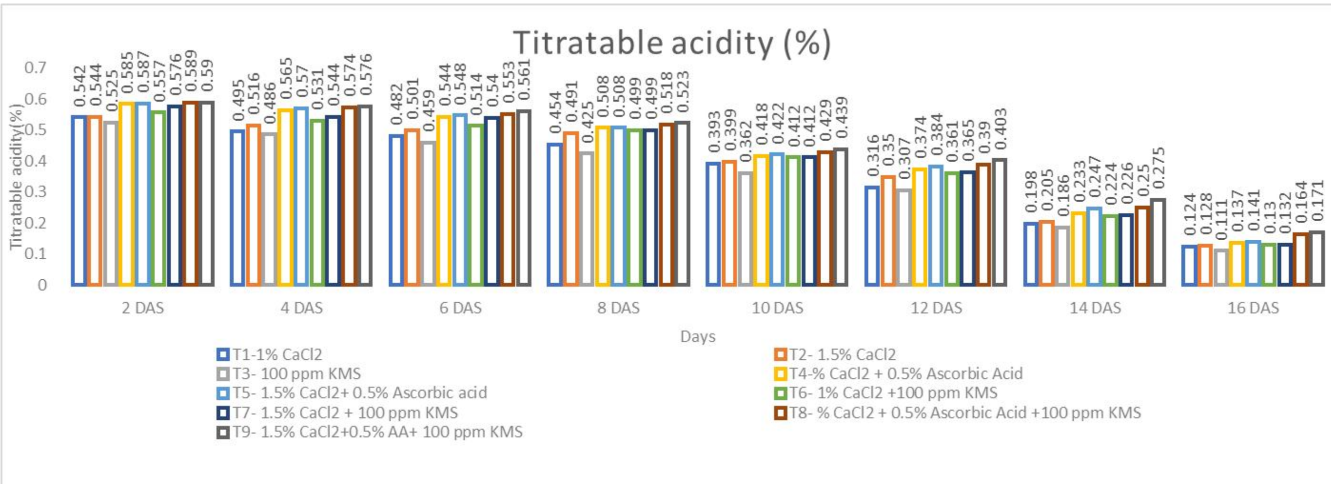

Fig. 2 : Effect of pre-treatments on Titratable acidity (%) of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

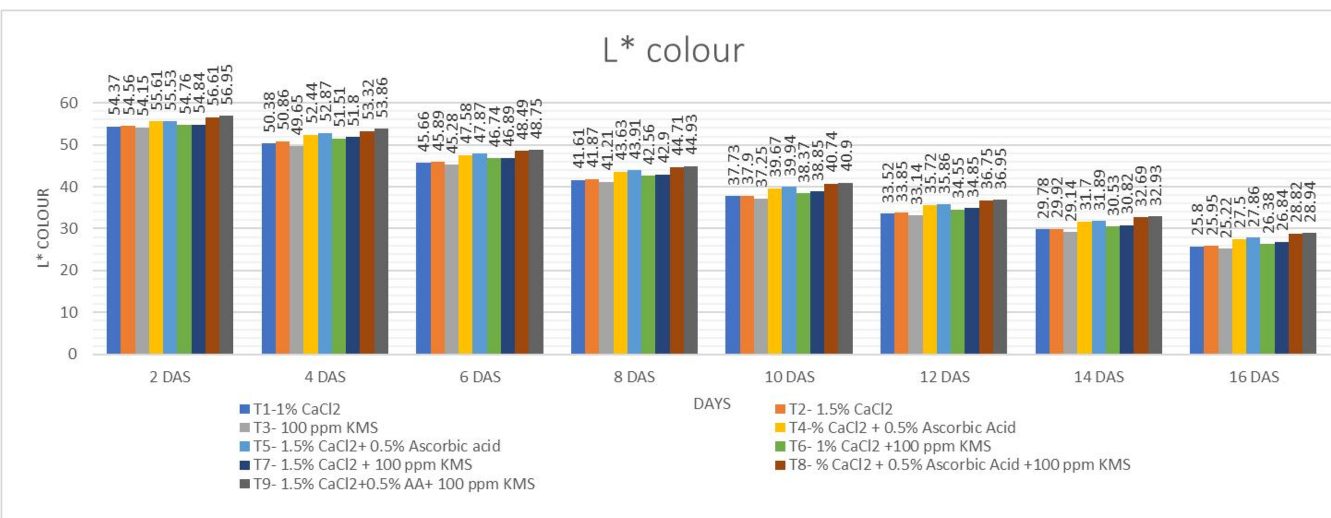

Fig. 3 : Effect of pre-treatments on *L** colour value of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

consumer preference. During storage, L* values decreased from 55.26 to 27.03, with the highest L* in T_9 (43.03), followed by T_8 (42.77), and the lowest in T_3 (39.38). Similarly, b* values decreased from 53.92 to 25.90, with T_9 (41.81) showing the highest value. These results suggest T_9 is the best treatment for maintaining color. The preservation of color quality, attributed to ascorbic acid and calcium chloride, reduced oxidative browning and carotenoid loss. The anti-browning effects of ascorbic acid, facilitated by its radical scavenging and

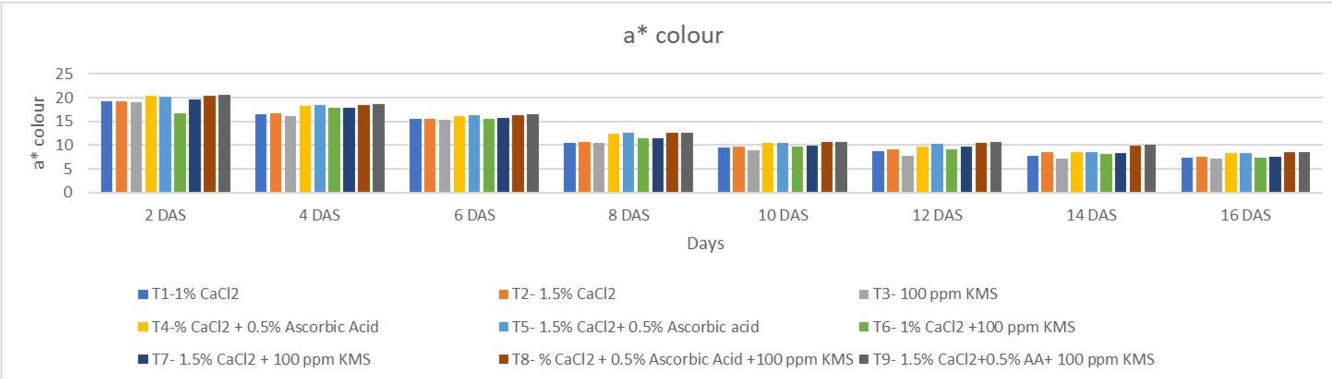

Fig. 4 : Effect of pre-treatments on *a** colour value of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

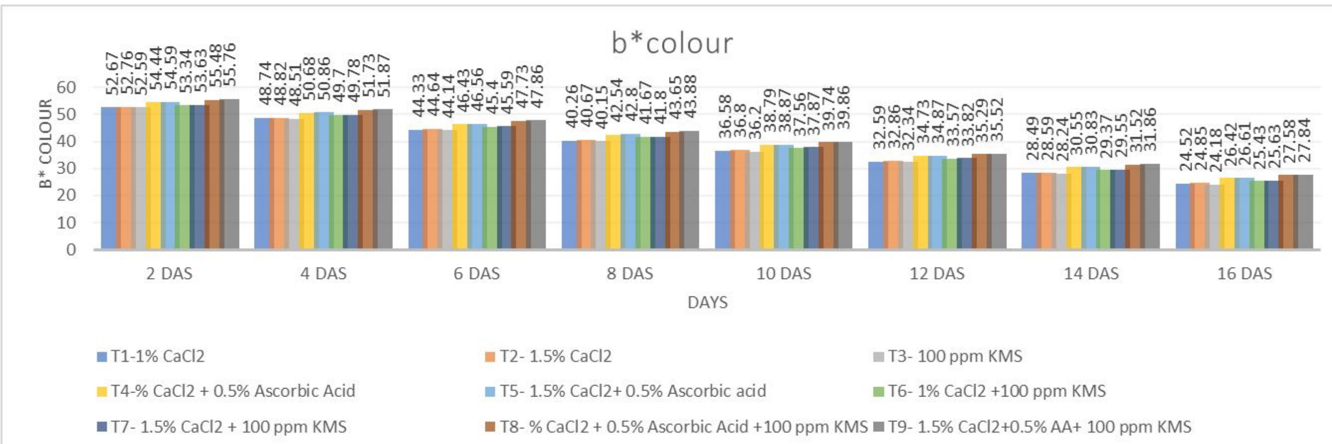

Fig. 5 : Effect of pre-treatments on *b** colour value of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

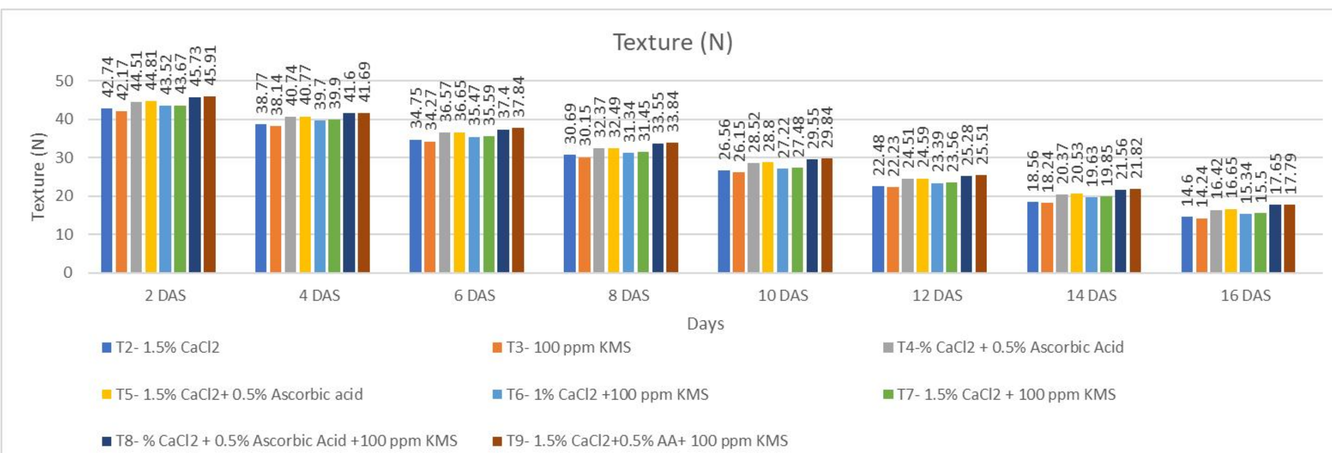

Fig. 6: Effect of pre-treatments on texture (N) of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

oxygen absorption properties, along with low oxygen conditions, helped retain colour and prevent enzymatic browning during storage (Varela *et al.*, 2007).

Effect of different pre treatments on texture (N)

Calcium (Ca^{2+}) is crucial for plant cell wall structure, membrane stability, and signaling. It plays a key role in postharvest biology, influencing processes like fruit ripening, senescence and enzymatic activity. In jackfruit bulbs, texture values decreased during storage (Fig. 6), with T_9 showing the highest retention of firmness, followed by T_8. Calcium chloride ($CaCl_2$) treatments help preserve texture by preventing the synthesis of cell wall-degrading enzymes and forming calcium pectate, which restricts pectin solubilization and reduces electrolyte leakage (Trindade *et al.*, 2002). This effect, noted in various studies, results in better texture retention and lower juice

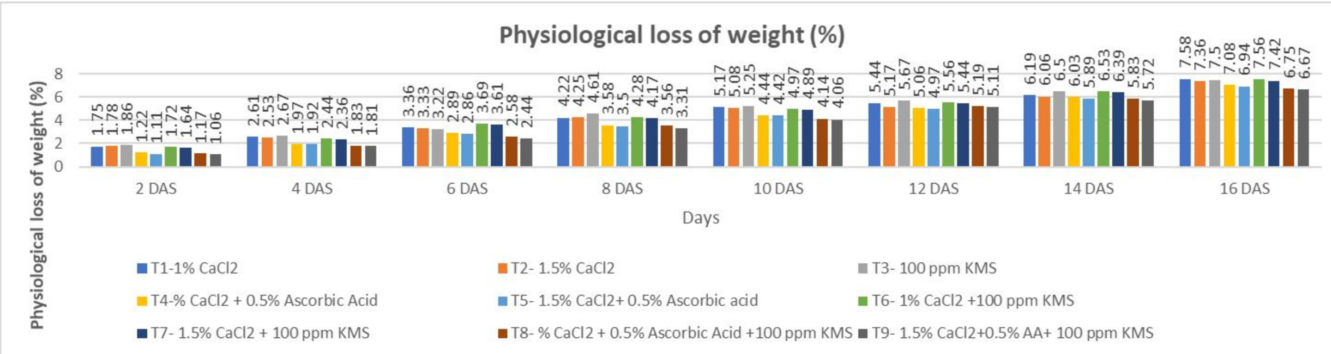

Fig. 7 : Effect of pre-treatments on physiological loss of weight (%) of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

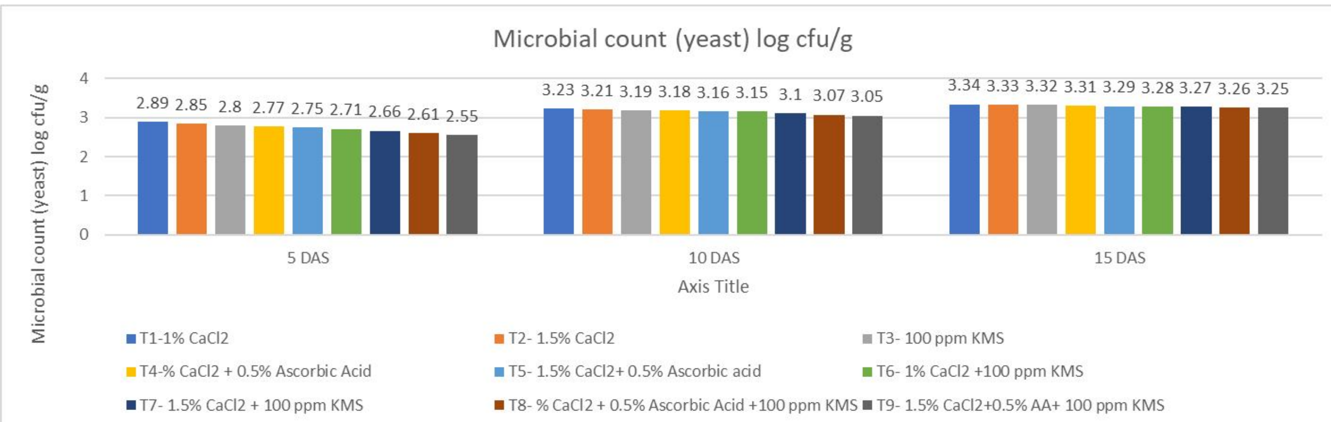

Fig. 8 : Effect of pre-treatments on yeast count of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

leakage due to less cellular breakdown. Enzymatic hydrolysis of cell wall components, like pectin and cellulose, accelerates fruit softening during storage, linked to increased polygalacturonase (PG) and pectin methylesterase (PME) activity. Calcium-based treatments can help slow this process, maintaining firmness and extending shelf life (Karakurt and Hubber, 2003).

Effect of different pre treatments on physiological loss of weight (%)

Temperature management is critical for maintaining the quality and shelf life of jackfruit bulbs. During storage (Fig. 7), the physiological loss of weight (PLW) increased from 1.48% to 7.21%, with the lowest PLW observed in treatment T_9 (3.77%) and the highest in T_3 (4.64%) under refrigeration at 4°C. This suggests that the combination of sealed packaging and low temperature reduced respiration rates, thereby minimizing weight loss, though not significantly. Moisture loss occurs as the product's tissues continue respiring. Elevated ethylene levels can increase respiration, leading to further weight loss. Proper temperature control also impacts gas exchange, with lower temperatures reducing oxygen and increasing carbon dioxide in the tissue, thereby slowing water loss. Modified atmosphere packaging helps limit moisture loss, preserving the saleable weight and delaying senescence in minimally processed products.

Effect of different pre treatments on Microbial count (log cfu/g), Yeast count (log cfu/g), Bacterial count (log cfu/g)

Foods, while being a key source of nutrients, also provide an excellent environment for microorganism growth, including harmful pathogens. Pretreatment of jackfruit bulbs (Figs. 8 and 9) with calcium chloride, ascorbic acid, and potassium metabisulphite helps inhibit spoilage microorganisms, prevent browning, and preserve the fruit's structure and nutritional value (Saxena *et al.*, 2007). During refrigerated storage (4°C), yeast and bacterial counts were lowest in bulbs treated with potassium metabisulphite (T_9) and highest in untreated bulbs (T_1). This antimicrobial treatment effectively controls microbial growth, as low pH and low temperatures further suppress microbial activity in minimally processed foods (Abadias *et al.*, 2008).

Effect of different pre treatments on Sensory evaluation

Sensory evaluation is the scientific process of measuring and interpreting reactions to food based on senses like smell, sight, taste, touch and hearing. A

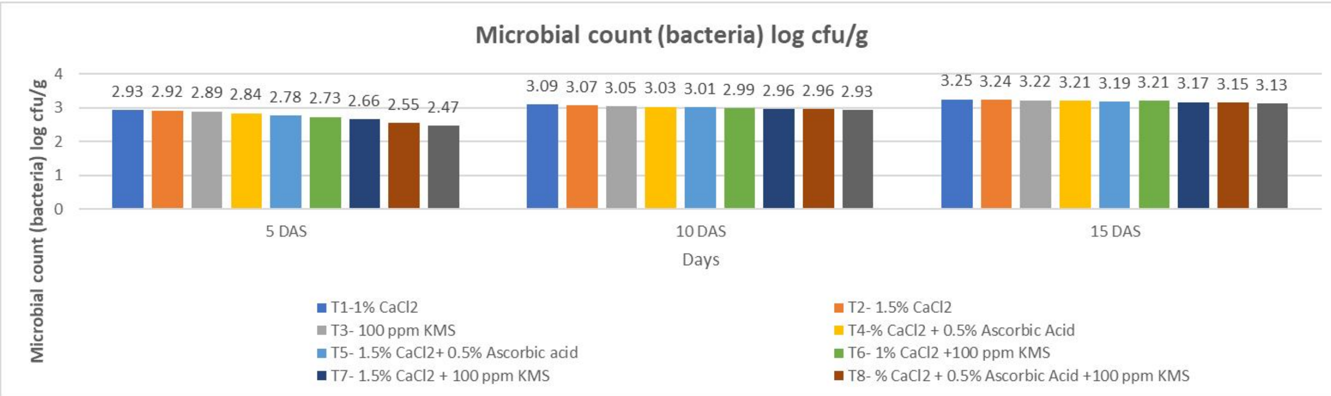

Fig. 9 : Effect of pre-treatments on bacterial count of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

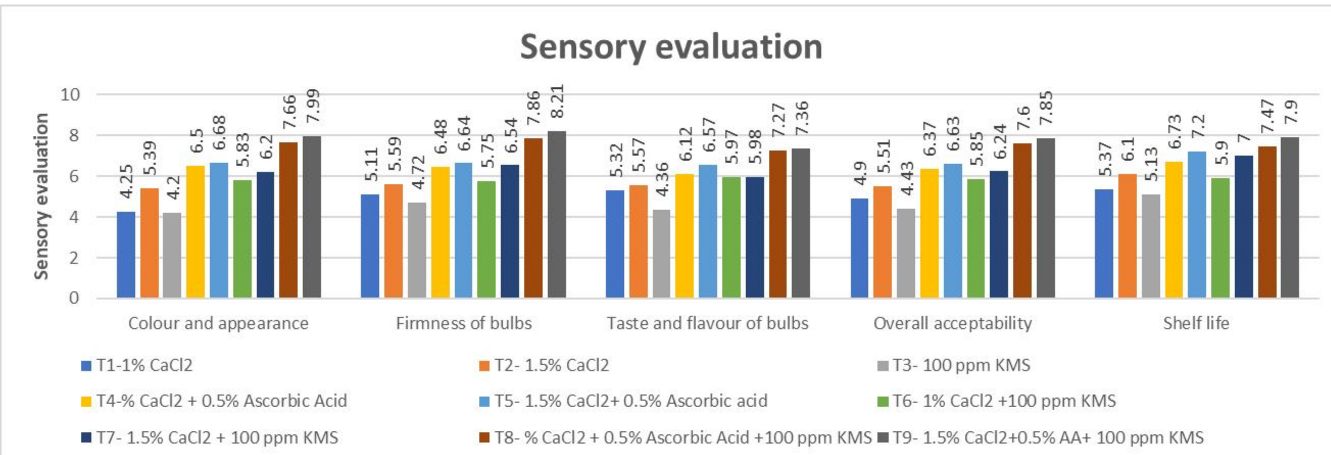

Fig. 10 : Effect of pre-treatments on sensory evaluation of jackfruit bulbs packed in stand-up pouches under refrigerated condition (4°C).

product's appearance significantly influences how it is perceived, including its taste. Quality in fresh fruits is defined by attributes that give value as food, with importance varying based on the fruit's intended use (fresh or processed) and the perspectives of producers, retailers, and consumers. Appearance, firmness and shelf life are key for marketers, while consumers prioritize freshness, firmness, flavor and nutritional value, as fruits provide essential nutrients and bioactive compounds that promote health (Kader, 1999).

Colour and appearance

The 9-point hedonic scale score for the color and appearance of pretreated jackfruit bulbs decreased over storage from 7.20 to 1.58 (Fig. 10). Significant differences ($p<0.05$) were observed among the treatments, with the highest score under refrigeration (4°C) in T_9 (7.99), followed by T_8 (7.66) and the lowest in T_3 (4.20), indicating T_9 as the best treatment. This decline in appearance is likely due to browning during storage. Saxena *et al.* (2009) noted that preservatives should be used minimally in processed jackfruit to avoid affecting sensory qualities. Additionally, calcium chloride helped preserve texture, as reported by Kubasa *et al.* (2011).

Firmness of bulbs

The 9-point hedonic scale score for firmness of pretreated jackfruit bulbs (Fig. 10) decreased during storage from 7.35 to 1.64, with significant differences ($p<0.05$) between treatments. Under refrigeration (4°C), T_9 had the highest firmness score (8.21), followed by T_8 (7.86) and the lowest was in T_3 (4.72). The use of $CaCl_2$ helped maintain firmness by preventing cell wall degradation through calcium pectate formation. Saxena *et al.* (2009) emphasized that texture and flavor are key factors in determining the shelf-life of pre-cut jackfruit bulbs. Sensory scores for overall acceptability varied significantly, with surface browning and texture loss aligning with changes in firmness and color. However, dip-treated bulbs showed better firmness, with shelf-life determined by a threshold sensory score of 5.0.

Taste and flavour

The 9-point hedonic scale score for firmness of pretreated jackfruit bulbs (Fig. 10) decreased during storage from 7.35 to 1.64, with significant differences ($p<0.05$) between treatments. Under refrigeration (4°C), T_9 had the highest firmness score (8.21), followed by T_8 (7.86) and the lowest was in T_3 (4.72). The use of $CaCl_2$ helped maintain firmness by preventing cell wall degradation through calcium pectate formation. Saxena *et al.* (2009) emphasized that texture and flavor are key factors in determining the shelf-life of pre-cut jackfruit bulbs. Sensory scores for overall acceptability varied significantly, with surface browning and texture loss aligning with changes in firmness and color. However, dip-treated bulbs showed better firmness, with shelf-life determined by a threshold sensory score of 5.0.

Overall acceptability and shelf life

The 9-point hedonic scale score for taste and flavour of pretreated jackfruit bulbs (Fig. 10) was highest in T_9 (7.36), followed by T_8 (7.27) and lowest in T_3 (4.36), with significant differences ($p<0.05$) between treatments. Similarly, T_9 had the highest overall acceptability score (7.85) and longest shelf life (7.9 days), followed by T_8 (7.4 days) and T_3 (5.1 days). The extended shelf life in T_9 is attributed to its treatment with 1.5% calcium chloride, 0.5% ascorbic acid, and 100 PPM potassium metabisulphite, which preserved texture, color, and microbial stability. The treatment also inhibited microbial growth, maintaining sensory and microbial quality during storage. The absence of coliforms ensured product safety, while the hurdle effect reduced the bacterial load. Overall, T_9 proved to be the best treatment based on low weight loss, high sensory scores and stable microbial characteristics (Saxena *et al.*, 2009).

Conclusion

Effect of different pre treatments on shelf life of jackfruits bulbs among all the treatments the treatment 9 *i.e.*, 1.5% $CaCl_2$+ 0.5% AA+ 100 ppm KMS recorded low TSS, high titratable acidity, good *L** and *b** values, high firmness, less physiological loss of weight, low microbial count and highest score in sensory evaluation. Among all the pre treatments with different time interval, it is found that treatment T_9 showed highest shelf life of 16 days compared to other treatments. Hence, the treatment 9 *i.e.*, 1.5% $CaCl_2$+ 0.5% AA+ 100 ppm KMS was found best treatment to extend the shelf life of jackfruit bulbs upto 16 days compared to other treatments.

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Conflict of interest : The authors declare that they have no conflict of interest.

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