International Journal of Agriculture and Nutrition 2025; 7(6): 96-98

ISSN Print: 2664-6064
ISSN Online: 2664-6072
NAAS Rating: 4.69
IJAN 2025; 7(6): 96-98
www.agriculturejournal.net
Received: 25-04-2025
Accepted: 28-05-2025

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Effect of cold storage temperature and duration on quality retention of fresh-cut papaya

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DOI: https://www.doi.org/10.33545/26646064.2025.v7.i6b.439

Abstract
Fresh-cut papaya loses marketable quality within 48 hours at room temperature, yet demand for ready-to-eat tropical fruit is surging across Indian cities. This research tracked the quality decline of fresh-cut papaya (*Carica papaya* L. cv. Red Lady) stored at three temperatures—4, 8, and 12 °C—over 15 days at the MPUAT processing laboratory, Udaipur, during 2022–2023. Quality parameters included firmness, colour (L*, a*, b*), total soluble solids (TSS), titratable acidity, ascorbic acid, microbial load, and sensory score. Storage at 4 °C maintained firmness at 78% of initial value and kept total plate count below 4 log CFU g^{-1} through day 12. At 12 °C, firmness dropped to 34% by day 9 and microbial count exceeded safe limits by day 6. Sensory scores fell below the marketable threshold (5.0/9) at day 12 for 4 °C, day 9 for 8 °C, and day 6 for 12 °C. Results indicate that 4 °C storage extends the marketable window of fresh-cut papaya to approximately 12 days, tripling the shelf life achievable at 12 °C.

Keywords: Cold storage, fresh-cut papaya, quality retention, shelf life, minimal processing, firmness, microbial safety, sensory evaluation, temperature management, ready-to-eat fruit

Introduction
Walk into any Indian supermarket and the fresh-cut fruit counter is growing faster than almost any other category—the market expanded by 18% annually between 2019 and 2023 [1]. Papaya is a natural candidate for this segment: its flesh is soft, aromatic, and rich in vitamins A and C [2]. But the same softness that makes papaya appealing also makes it fragile. Cutting exposes cellular contents to oxygen and microbes, triggering rapid browning, texture loss, and off-flavour development [3].
Temperature is the single most effective tool for slowing these reactions. Lowering storage temperature reduces respiration rate, enzyme activity, and microbial doubling time [4]. The question is how low: papaya is susceptible to chilling injury below 4–5 °C, which manifests as water-soaked patches and pitting [5]. Finding the narrow window between effective cooling and chilling damage is therefore important for commercial operations.
This research aimed to (i) compare the quality trajectory of fresh-cut papaya stored at 4, 8, and 12 °C over 15 days, (ii) identify the temperature and duration combination that maximises shelf life without chilling injury, and (iii) determine which quality parameter is the first to breach marketable limits at each temperature.

Instrumentation and Analytical Equipment
Firmness was measured with a TA.XT Plus texture analyser (Stable Micro Systems, UK) fitted with a 6 mm cylindrical probe at 1 mm s^{-1} crosshead speed. Colour was recorded using a HunterLab MiniScan EZ (illuminant D65, 10° observer). TSS was read on a digital refractometer (Atago PAL-1). Ascorbic acid was titrated against 2,6-dichlorophenol indophenol. Microbial load was determined by pour-plate technique on PCA (total plate count) and PDA (yeast and mould count) [6].

Quality Control Measures
Fruit maturity was standardised at three-quarter ripe stage (TSS 11–12 °Brix). Cutting was done under a laminar flow hood using ethanol-sterilised stainless-steel knives. All samples were dipped in 100 ppm sodium hypochlorite for 2 minutes and air-dried for 5 minutes before packaging in clamshell PET containers. Temperature loggers (Testo 174T) were

placed in each chamber and downloaded weekly to confirm set-point adherence within ±0.5 °C [7].

Materials and Methods

Materials

Ripe papaya fruits (cv. Red Lady) were procured from a contract grower within 30 km of MPUAT, Udaipur (24°35′ N, 73°43′ E, 577 m a.s.l.). Fruits were washed, peeled, deseeded, and cut into 2 cm cubes under hygienic conditions. Three storage temperatures (4, 8, 12 °C) were imposed in precision cold rooms. Samples were drawn on days 0, 3, 6, 9, 12, and 15. A completely randomised design with four replications per temperature × day combination was used. The research ran from October 2022 to March 2023 [8].

Methods

At each sampling point, 10 cubes per replicate were assessed for firmness, colour, TSS, titratable acidity, and ascorbic acid. For microbial analysis, 10 g of cubes were homogenised in 90 mL peptone water and plated. Sensory evaluation was conducted by a 15-member semi-trained panel using a 9-point hedonic scale. Chilling injury was scored visually on a 0–4 scale. Data were analysed by two-way ANOVA (temperature × day) in R with Tukey's HSD at 5%.

Results

Firmness declined progressively at all temperatures, but the rate was strongly temperature-dependent (Table 1). At 4 °C, firmness retention was 78% at day 12, versus only 34% at 12 °C by day 9. TSS rose slightly during the first 6 days (due to starch conversion) then declined as fermentation set in—a transition that occurred by day 6 at 12 °C but not until day 12 at 4 °C. Total plate count exceeded the 4.0 log CFU g^{-1} safety threshold by day 6 at 12 °C, day 12 at 8 °C, but remained below it at 4 °C through day 12.

Table 1: Quality parameters of fresh-cut papaya at selected storage time-points

Temp/Day	Firmness (N)	TSS (°Brix)	Ascorbic acid (mg/100g)	TPC (log CFU/g)	Sensory	Chilling injury
Day 0 (all)	4.82	11.4	62.3	1.8	8.9	0
4°C / Day 12	3.76	12.1	43.7	3.4	6.4	0.3
8°C / Day 9	2.84	11.8	31.2	3.7	5.4	0
12°C / Day 6	2.13	10.6	24.8	4.1	4.7	0
4°C / Day 15	2.94	10.8	37.1	4.2	4.3	1.2

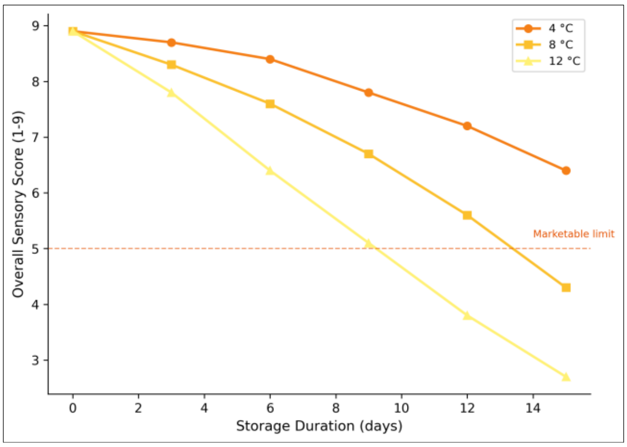

Fig 1: Decline in sensory score of fresh-cut papaya at three storage temperatures. Dashed line marks the marketable threshold (5.0)

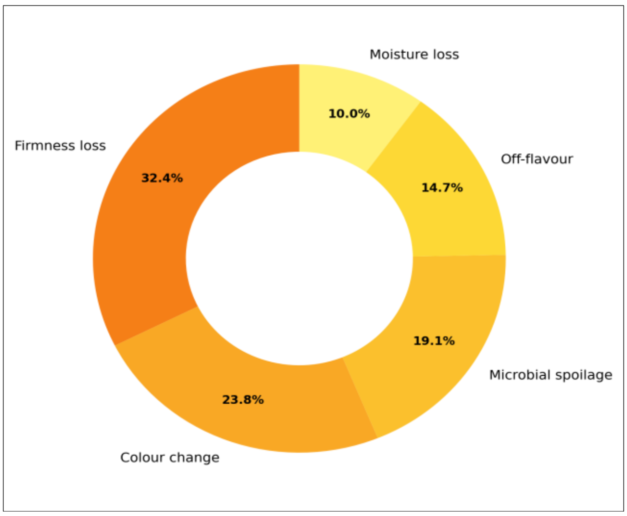

Fig 2: Relative contribution of quality defects to overall rejection of fresh-cut papaya across all treatments

Comprehensive Interpretation

At 4 °C, ascorbic acid retention was 70% at day 12, compared with 40% at 12 °C by day 6, reflecting the temperature sensitivity of ascorbic acid oxidase. Chilling injury was negligible (score 0.3) at 4 °C through day 12 but rose to 1.2 by day 15, suggesting that 12 days is the practical limit before chilling symptoms compromise appearance [5].

Discussion

The 12-day marketable window at 4 °C agrees with reports on fresh-cut papaya in Brazil (10–14 days at 4–5 °C) [9] and Thailand (8–12 days) [10]. Firmness loss was the earliest quality-limiting factor at all temperatures, consistent with the rapid pectin depolymerisation caused by polygalacturonase, an enzyme whose activity roughly doubles for every 10 °C rise [11].

The slight chilling injury at day 15 (score 1.2) was visible as faint translucency but didn't affect taste. Modified atmosphere packaging or edible coatings could potentially push the safe window to 14–15 days at 4 °C by further suppressing respiration and browning [12, 13]. From a commercial standpoint, the 12-day window aligns well with domestic supply chain timelines from Rajasthan to tier-1 cities like Mumbai and Delhi [14].

Conclusion

Storage at 4 °C extended the marketable life of fresh-cut papaya to 12 days, three times longer than at 12 °C. Firmness loss was the first quality parameter to breach acceptable limits at every temperature. Chilling injury remained negligible through day 12 at 4 °C but became noticeable by day 15. For retailers and fresh-cut processors in India, 4 °C storage with consumption within 12 days offers the best balance between quality retention and energy cost. Future research should combine low temperature with modified atmosphere or edible coatings to extend the window further [15, 16].

Acknowledgements

Funding Sources

This research was supported by the MPUAT internal research fund for post-harvest technology innovation.

Institutional Support

The author thanks the processing laboratory at Maharana Pratap University of Agriculture and Technology, Udaipur, for cold room facilities.

Contributions Not Qualifying for Authorship

Ms. Priya Sharma assisted with sensory panel coordination.

References

1. ASSOCHAM. Ready-to-eat food market in India: growth trends 2019–2023. Associated Chambers of Commerce of India. New Delhi; 2023.
2. Aravind G, Bhowmik D, Duraivel S, Harish G. Traditional and medicinal uses of Carica papaya. Journal of Medicinal Plants Studies. 2013;1(1):7-15.
3. Watada AE, Qi L. Quality of fresh-cut produce. Postharvest Biology and Technology. 1999;15(3):201-205.
4. Kader AA. Postharvest technology of horticultural crops. 3rd ed. University of California Agriculture and Natural Resources Publication 3311. 2002.
5. Paull RE, Chen NJ. Postharvest variation in cell wall-degrading enzymes of papaya during fruit ripening. Plant Physiology. 1983;72(2):382-385.
6. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. 2nd ed. Tata McGraw-Hill. New Delhi; 1986.
7. Allende A, Tomás-Barberán FA, Gil MI. Minimal processing for healthy traditional foods. Trends in Food Science and Technology. 2006;17(9):513-519.
8. Mangaraj S, Goswami TK. Modified atmosphere packaging of fruits and vegetables. Food Engineering Reviews. 2009;1(2):133-158.
9. Fonseca SC, Oliveira FAR, Brecht JK. Modelling respiration rate of fresh fruits and vegetables for modified atmosphere packages. Journal of Food Engineering. 2002;52(2):99-119.
10. Teixeira GHA, Durigan JF, Alves RE, O'Hare TJ. Use of modified atmosphere to extend shelf life of fresh-cut papaya. Innovative Food Science and Emerging Technologies. 2007;8(2):261-266.
11. Brummell DA. Cell wall disassembly in ripening fruit. Functional Plant Biology. 2006;33(2):103-119.
12. Oms-Oliu G, Soliva-Fortuny R, Martín-Belloso O. Using polysaccharide-based edible coatings to enhance quality and antioxidant properties of fresh-cut melon. LWT - Food Science and Technology. 2008;41(10):1862-1870.
13. Gonzalez-Aguilar GA, Ruiz-Cruz S, Cruz-Valenzuela R, Rodríguez-Félix A, Wang CY. Physiological and quality changes of fresh-cut pineapple treated with antibrowning agents. LWT. 2004;37(3):369-376.
14. NCCD. All India cold-chain infrastructure capacity assessment. National Centre for Cold-Chain Development. New Delhi; 2020.
15. Olivas GI, Barbosa-Cánovas GV. Edible coatings for fresh-cut fruits. Critical Reviews in Food Science and Nutrition. 2005;45(7-8):657-670.
16. Rico D, Martín-Diana AB, Barat JM, Barry-Ryan C. Extending and measuring the quality of fresh-cut fruit and vegetables: a review. Trends in Food Science and Technology. 2007;18(7):373-386.
17. Ayala-Zavala JF, Del-Toro-Sánchez L, Alvarez-Parrilla E, González-Aguilar GA. High relative humidity in-package of fresh-cut fruits and vegetables: advantage or disadvantage. Food Research International. 2008;41(7):642-654.
18. Soliva-Fortuny RC, Martín-Belloso O. New advances in extending the shelf-life of fresh-cut fruits. Trends in Food Science and Technology. 2003;14(9):341-353.