Journal of Current Science and Technology, October-December 2025 Vol. 15 No. 4, Article 133

ISSN 2630-0656 (Online)

Cite this article: Kenkhunthot, T., Onsri, K., & Nathaweesap, B. (2025). Postharvest quality preservation of 'Thongprasert' jackfruit through combination of H_2O_2 and 1-Methylcyclopropene. *Journal of Current Science and Technology*, *15*(4), Article 133. https://doi.org/10.59796/jcst.V15N4.2025.133

Journal of Current Science and Technology

Journal homepage: https://jcst.rsu.ac.th

Postharvest Quality Preservation of 'Thongprasert' Jackfruit Through Combination of H_2O_2 and 1-Methylcyclopropene

Tanatya Kenkhunthot[1,*], Kasideth Onsri[2], and Bunnavit Nathaweesap[1]

[1]Faculty of Agricultural Innovation, College of Agricultural Innovation and Food Technology, Rangsit University, Pathum Thani 12000, Thailand

[2]Department of Agricultural Extension and Communication, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand

*Corresponding author; E-mail: siri.k@rsu.ac.th

Received 17 May 2025; Revised 14 June 2025; Accepted 17 June 2025; Published online 20 September 2025

Abstract

The rapid postharvest deterioration of 'Thongprasert' jackfruit (*Artocarpus heterophyllus* Lam. cv. 'Thongprasert') poses significant challenges for export and commercial distribution. This study evaluated the combined effects of hydrogen peroxide (H_2O_2) and 1-methylcyclopropene (1-MCP) on extending shelf life and maintaining postharvest quality during cold storage. A completely randomized design was applied with five treatments: untreated control, 0.175% H_2O_2 alone, and 0.175% H_2O_2 combined with 1-MCP at concentrations of 0.03%, 0.06%, and 0.09%. Fruits were stored at 13 ± 1°C and assessed on days 5, 10, 15, and 20 for percentage weight loss, peel and flesh color (L*, a*, b*), firmness, total soluble solids (TSS), and disease incidence. The results showed that H_2O_2 combined with 1-MCP significantly reduced percentage weight loss, with the 0.09% 1-MCP treatment exhibiting the lowest loss after 20 days. However, for other quality parameters such as color, firmness, and TSS, the differences between the 0.06% and 0.09% 1-MCP treatments were not always statistically significant. Peel color retention was improved, with significantly lower L* (day 15) and a* (day 5) values observed in the treated groups. TSS levels increased over time in all treatments, with no significant differences among them, although values were generally higher than in the control. Disease incidence was significantly reduced in all H_2O_2 + 1-MCP treatments from day 10 onward, indicating strong antimicrobial effects. In conclusion, the combined application of 0.175% H_2O_2 and 0.06% 1-MCP was the most effective in prolonging shelf life and maintaining postharvest quality of 'Thongprasert' jackfruit during cold storage. These findings support its potential integration into commercial postharvest handling and export protocols to reduce the postharvest losses and preserve fruit quality.

Keywords**:** *jackfruit; Thongprasert; 1-MCP; hydrogen peroxide; shelf life; postharvest quality; cold storage; food preservation*

1. Introduction

Jackfruit (*Artocarpus heterophyllus* Lam. cv. 'Thongprasert') is a widely consumed tropical fruit in Southeast Asia and plays a significant economic role in Thailand's fruit export industry (Pragalyaashree et al., 2023). Renowned for its large size, thin peel, minimal fiber, crispy flesh, golden-yellow color, sweet taste, and distinctive aroma, it is highly favored and valued in both domestic and international markets (Pragalyaashree et al., 2023). Annual jackfruit production in Thailand is substantial, estimated at 300,000 to 392,000 metric tons (Tridge, 2025). Economically, jackfruit has become an important export commodity for Thailand. The Geographical Indication (GI) registration of "Nong Hiang Chon Buri Jackfruit," which includes the 'Thongprasert' variety, has enhanced its market value and global recognition, resulting in increased income for local

farmers and communities. Thailand consistently ranks among the top jackfruit exporters worldwide and was the largest exporter in 2023–2024, with an export value of US$760.74 million (Tridge, 2023). The fruit's growing export demand underscores the need for effective postharvest strategies to maintain quality and reduce losses during distribution.

Nutritionally, 'Thongprasert' jackfruit is a rich source of essential macro- and micronutrients, making it a valuable functional food. Per 100 g of raw flesh, it contains approximately 23.25 g of carbohydrates, 19.08 g of natural sugars, 1.5 g of dietary fiber, 0.64 g of fat, and 1.72 g of protein (Taikerd, & Leelawat, 2023). It is particularly notable for its content of B-complex vitamins, especially vitamin B6 (25% RDI), as well as vitamin C (17% RDI), vitamin A, and antioxidant compounds such as β-carotene, lutein, and zeaxanthin, which contribute to immune and visual health (Ranasinghe et al., 2019). The mineral profile of raw jackfruit flesh per 100 g fresh weight includes potassium (448 mg), magnesium (29 mg), calcium (34 mg), and phosphorus (21 mg), supporting cardiovascular function, electrolyte balance, and bone health (Booth, & Altomara, 2024). With its high fiber content and antioxidant capacity, jackfruit contributes to satiety, digestive wellness, and reduced oxidative stress, underscoring its growing popularity as a health-promoting tropical fruit (Ranasinghe et al., 2019).

Despite its significant economic contribution and nutritional richness, the postharvest handling of 'Thongprasert' jackfruit presents considerable challenges. As a climacteric fruit, it continues to ripen after harvest, leading to a rapid increase in ethylene production and respiration rates (Hewitt, & Dhingra, 2020), which accelerates spoilage. This spoilage includes excessive moisture loss, fruit softening, peel discoloration due to chlorophyll degradation, and microbial contamination, all of which compromise the marketability and shelf life of the fruit (Arista, & Ardiningtyas, 2024; Osiripun & Labua, 2023). Consequently, 'Thongprasert' jackfruit deteriorates quickly after harvest when stored under ambient conditions, typically lasting a shelf life of about 7 days (Pomasa et al., 2024). While refrigerated storage at temperatures between 8–10°C can extend this to approximately 10–12 days, and storage at 13± 1°C with 85–90% relative humidity can prolong it to 2–6 weeks, quality attributes such as texture, sweetness, and appearance often deteriorate without specialized treatments (Ying et al., 2020). Delays in transportation or inadequate storage conditions can exacerbate quality deterioration, including browning, peel cracking, and overripening (Rattanapakdee, 2024; Kaur et al., 2024).

Hence, given jackfruit's postharvest shelf life limitations and the increasing demand in export markets, research into effective postharvest treatments is essential. Conventional postharvest practices such as harvesting at physiological maturity (120–160 days), manual detachment, and wrapping in protective materials are standard. Many researchers have reported using 1-MCP for its ability to inhibit ethylene action, thereby slowing down ripening, softening, and senescence (Morelos-Flores et al., 2023; Zhang et al., 2020). Independently, hydrogen peroxide (H_2O_2) is widely recognized for its broad-spectrum antimicrobial activity (Meng et al., 2019; Onsrisawat et al., 2022; de Siqueira Oliveira et al., 2018) with concentrations typically ranging from 0.1% to 2%, depending on fruit sensitivity. Studies have shown that a concentration around 0.175% can achieve effective microbial load reduction while minimizing potential peel damage (Sahoo et al., 2021), helping to suppress microbial growth and reduce decay incidence during storage of fruits like citrus, melons, and berries (Abdelshafy et al., 2024). While both treatments have demonstrated effectiveness when used independently, there remains a limited understanding of their combined effects, particularly in jackfruit. In particular, their impact on maintaining key quality parameters such as weight retention, firmness, peel and flesh color, sweetness, and disease suppression in 'Thongprasert' jackfruit has not been systematically explored.

To address this knowledge gap and the postharvest challenges associated with 'Thongprasert' jackfruit, this study investigated the efficacy of a combined treatment of 0.175% H_2O_2 and varying concentrations of 1-MCP on prolonging shelf life and preserving fruit quality under export-relevant conditions at 13± 1°C. This dual-action approach aims to address both microbial and physiological deterioration, potentially offering a safe, low-residue, and commercially viable postharvest treatment protocol for jackfruit.

2. Objectives

This study aimed to evaluate the effect of postharvest coating with H_2O_2 and varying concentrations of 1-MCP on the quality and shelf life of 'Thongprasert' jackfruit stored at 13± 1°C, focusing on parameters such as %weight loss, firmness, peel and flesh color changes, Total Soluble Solids (TSS), and microbial decay.

3. Materials and Methods

3.1 Raw Materials

'Thongprasert' jackfruits were sourced from Prachuap Khiri Khan Province. A total of 40 fruits (Grade C; green; nearly round; 8–12 kg) were selected. Each fruit had an average weight of approximately 10 kg and was free from mechanical damage, insect infestation, and disease symptoms. Only fruits with uniform shape and surface appearance were included.

3.2 Experimental Design

A completely randomized design (CRD) was employed, consisting of **five postharvest treatments** with two replications per treatment. The treatments were as follows:

- **T1 (Control):** No treatment
- **T2:** Sprayed with 0.175% hydrogen peroxide (H_2O_2)
- **T3:** Sprayed with 0.175% H_2O_2 + 0.03% 1-methylcyclopropene (1-MCP)
- **T4:** Sprayed with 0.175% H_2O_2 + 0.06% 1-MCP
- **T5:** Sprayed with 0.175% H_2O_2 + 0.09% 1-MCP

Each treatment group was evaluated at four storage intervals: days 5, 10, 15, and 20 after storage at 13 ± 1°C. At each interval, two fruits per treatment were randomly selected for analysis. Measurements for each parameter were taken on both fruits, and the average value was calculated for each treatment. The selected H_2O_2 concentration (0.175%) was based on previous studies demonstrating its efficacy in postharvest fruit preservation and safety for use (Sahoo et al., 2021; de Siqueira Oliveira et al., 2018).

3.3 Sample Preparation

A 0.175% H_2O_2 solution was prepared by diluting 5 mL of 35% H_2O_2 in 1 L of distilled water. Twenty milliliters of this solution were uniformly sprayed over each fruit in T2–T5. For 1-MCP application, the treated groups (T3–T5) received sachets moistened with the corresponding concentrations (0.03%, 0.06%, and 0.09%). Eight fruits per treatment were individually wrapped in kraft paper and stored together in the same storage chamber. Quality assessments were conducted at 5-day intervals on days 5, 10, 15, and 20 of storage.

3.4 Storage Procedure

The refrigerated storage chamber (2.4 m × 6 m × 2.5 m) was cleaned with tap water, dried, and disinfected with 70% ethanol. Temperature and sealing conditions were verified before sample loading. Each group (T1–T5) was placed in separate boxes equipped with thermometers to monitor internal temperatures. The chamber maintained a constant temperature of 13 ± 1°C. Samples were retrieved at 5-day intervals for analysis.

3.5 Data Collection

3.5.1 Weight Loss of The Jackfruit (%)

Weight loss of the Jackfruit was calculated from the difference between initial and recorded fresh weights at each interval using the formula:

$$\text{Weight Loss (\%)} = \frac{\text{(Initial Weight – Final Weight) x 100}}{\text{Initial Weight}}$$

3.5.2 Color Measurement (L, a*, b*)*

Peel color was assessed at three regions around the middle section of the fruit, which is considered a key indicator of jackfruit ripeness. Within each region, three consistent spots, each approximately 3 cm in diameter, were selected for measurement (Pathare et al., 2013; Puangwerakul et al., 2024). A portable colorimeter (D65 illuminant, 2° observer) was used. Flesh color was similarly measured on flat surfaces. Parameters included:

- **L*** (lightness: 0 = black, 100 = white)
- **a*** (positive = red; negative = green)
- **b*** (positive = yellow; negative = blue)

3.5.3 Flesh Firmness

Flesh firmness was measured to determine the maximum penetration force of the pulp. For each treatment and time point, two jackfruits were randomly selected. The outer peel was removed using a sharp knife to expose the inner pulp. A fruit firmness penetrometer (Model GY-03, CHINCAN) was used to measure resistance. The probe was pressed perpendicularly into the pulp surface, and the maximum force was recorded from the dial gauge. Measurements were taken at two equidistant points along the equatorial region of each fruit, avoiding seeds and fibrous areas. The firmness value per fruit was calculated as the average of the two readings, and the data from both fruits were used to compute the treatment mean. Results were expressed in Newtons (N).

3.5.4 Total Soluble Solids (TSS)

Ten grams of jackfruit pulp were homogenized with 10 mL of distilled water and filtered through muslin cloth. The resulting filtrate was measured using a handheld refractometer (ATAGO Master-80H) and expressed in °Brix. Since the sample was diluted 1:1, the recorded °Brix values were multiplied by 2 to estimate the actual TSS of the undiluted pulp.

3.5.5 Disease Incidence (%)

Digital images of jackfruit peel were analyzed using ImageJ (v1.53t). Disease and healthy areas were quantified, and the ratio of diseased area to total surface area was expressed as the percentage disease incidence.

3.6 Statistical Analysis

Data were analyzed using one-way analysis of variance (ANOVA), and treatment means were compared using the Least Significant Difference (LSD) test at $p \leq 0.05$, employing SPSS Statistics v22.

4. Results and Discussion

4.1 Percent Weight Loss

Table 1 presents the percentage weight loss of 'Thongprasert' jackfruit stored at 13 ± 1 °C for 20 days under different postharvest treatments. By day 5, significant differences were already observed among treatments ($p \leq 0.05$). Fruits treated with H_2O_2 + 1-MCP at 0.06% (T4) and 0.09% (T5) exhibited the lowest weight loss (0.93% and 0.87%, respectively), both significantly lower than the control (2.61%) and the H_2O_2-only treatment (3.17%). By days 10 and Day 15, weight loss continued to increase across all treatments, but no significant differences were detected among groups at these points due to higher variability (e.g., standard deviations in T2 and T3 exceeded 1.5%). This lack of statistical significance, despite apparent numerical differences, likely resulted from within-group variation and limited replication, reducing statistical power. On day 20, clear differences re-emerged. The T5 treatment (0.175% H_2O_2 + 0.09% 1-MCP) again showed the lowest weight loss (4.34%), significantly lower than the control group (T1: 5.78%) ($p \leq 0.05$). T4 (5.29%) and T3 (4.91%) also trended lower than the control but were not statistically different. These findings support the effectiveness of combining H_2O_2 and 1-MCP in reducing transpiration and respiration-induced weight loss, especially at higher concentrations of 1-MCP. This indicates that the synergistic use of 1-MCP with H_2O_2 could effectively maintain moisture content and reduce transpiration losses during storage (Ahmad et al., 2023). These results suggest that coating effectively reduced respiration rates, which are directly linked to fresh weight loss through the production of water, heat, and carbon dioxide during metabolic activity (Fagundes et al., 2013).

Overall, the combined treatments T4 and T5 effectively slowed weight loss and maintained fruit freshness during storage, consistent with previous findings by Plainsirichai et al., (2010) in similar fruit systems. The results indicate that synergistic effects between H_2O_2's antimicrobial barrier and 1-MCP's ethylene inhibition help suppress metabolic water loss, supporting postharvest quality retention in jackfruit.

Table 1 Weight loss data across all treatments and time points

Treatment	Day 5	Day 10	Day 15	Day 20
T1	$2.61\pm0.71^{a,C}$	2.30 ± 0.41^{C}	4.26 ± 0.37^{B}	$5.78\pm0.03^{a,A}$
T2	$3.17\pm0.24^{a,B}$	3.86 ± 1.60^{AB}	4.34 ± 0.35^{AB}	5.48 ± 0.20^{A}
T3	3.19 ± 0.99^{a}	2.82±0.92	4.18±1.68	4.91 ± 1.56^{bc}
T4	$0.93\pm0.07^{b,C}$	2.45 ± 0.91^{B}	3.80 ± 0.46^{B}	$5.29\pm0.43^{ab,A}$
T5	$0.87\pm0.03^{b,B}$	1.65 ± 0.45^{B}	3.17 ± 0.68^{A}	$4.34\pm0.39^{c,A}$
F test (column-wise)	*	ns	ns	*
Tukey (0.05)	0.32	2.28	2.05	0.67
%CV	18.94	32.80	17.92	10.12

Note: Values are presented as mean ± standard deviation (SD)

T1 = Control; T2 = 0.175% H_2O_2; T3 = 0.175% H_2O_2 + 0.03% 1-MCP; T4 = 0.175% H_2O_2 + 0.06% 1-MCP; T5 = 0.175% H_2O_2 + 0.09% 1-MCP

At Day 0, weight loss is 0% for all treatments because no storage time has passed, and the initial weight serves as the reference point

Different letters (a–c) within the same column indicate significant differences among treatments at the same storage day ($p \leq 0.05$)

Different letters (A–C) within the same row indicate significant differences across storage times within each treatment ($p \leq 0.05$)

The absence of letters indicates no significant differences were found in that comparison, either among treatments (column-wise) or across storage times (row-wise)

'ns' denotes no significant difference according to the F-test. Tukey's HSD was used for mean separation when the F-test indicated significance

4.2 Changes in Jackfruit Peel Color

Peel color changes over the 20-day storage period at 13± 1°C are presented in Table 2. The L* value, representing peel lightness, showed no significant differences among treatments on days 5, 10, and 20. However, on day 15, significant differences were observed ($p \leq 0.05$). The control group had the highest L* value (53.43), indicating lighter peel color, whereas samples treated with 0.175% H_2O_2 + 0.09% 1-MCP showed the lowest L* value (49.23), indicating a darker peel. This result suggests that the combination treatments may help delay surface discoloration. For a* value (green-red axis), on day 5, the control group exhibited significantly greater greenness (a* = −6.98) compared to T5 (−3.95), indicating that the control fruit was initially greener. However, from day 10 onward, T5-treated fruits consistently maintained lower (more negative) a* values than the control, suggesting better retention of green coloration and delayed chlorophyll degradation in the later stages of storage. Jackfruits treated with 0.175% H_2O_2 + 0.09% 1-MCP exhibited the least negative a value (−3.95), indicating a reduction in greenness compared to the control (−6.98). This pattern reflects the effect of 1-MCP in delaying chlorophyll degradation, thereby slowing peel yellowing. Similar findings were reported by Burana (2018), who observed delayed color change in bananas treated with 1-MCP. The b* value (yellow intensity), representing the yellow-blue component. Since no statistically significant differences ($p > 0.05$) were observed across any storage day within each treatment, b* values can be considered stable over time. Across all treatments, b* values showed a numerical increase over the 20-day storage period, indicating progressive yellowing. Moreover, initial b* values differed among treatments at Day 5, which may influence the interpretation of yellowing or ripening progression. Fluctuations in b* values may suggest measurement variability or experimental error, although these differences were not statistically significant.

When comparing across storage days, the L* value remained relatively stable in most treatments, except for the control, which exhibited a noticeable decrease from 51.37 (day 5) to 48.37 (day 10), before increasing slightly again. This indicates that untreated jackfruits experienced greater surface darkening during early storage, while treated fruits maintained better color stability. For the a* value, some fluctuations were observed, but no consistent pattern of change was evident across storage days in most treatments. This suggests that while treatments may influence initial greenness, the overall effect of storage time on a* values was limited. Similarly, b* values showed no significant changes across storage days within treatments, indicating that the yellow tone of the jackfruit peel was largely unaffected by storage duration or treatments.

Overall, H_2O_2 and 1-MCP treatments helped delay peel discoloration by maintaining lightness and greenness, while yellow hue remained stable during storage, supporting 1-MCP's role in delaying senescence by inhibiting ethylene action.

Table 2 Effect of postharvest treatments on peel color values (L*, a*, b*) of 'Thongprasert' jackfruit during 20 days of storage at 13±1 °C.

Treatment	L*				a*				b*			
	Day 5	**Day 10**	**Day15**	**Day20**	**Day 5**	**Day 10**	**Day15**	**Day20**	**Day 5**	**Day 10**	**Day15**	**Day20**
T1	51.37±1.43^{AB}	48.37±1.65^{B}	53.43±0.46^{a,A}	52.61±2.66 ^{AB}	-6.98±1.66^{a,A}	-3.55±0.38^{B}	-2.30±0.62^{ab,B}	-1.62±0.21^{b,B}	17.55±2.08	13.50±1.57	16.12±1.08^{a}	15.60±1.71
T2	49.95±1.65	50.53±2.23	49.92±1.37^{b}	50.68±1.27	-6.56±0.38^{ab,A}	-5.03±0.32^{B}	-0.95±0.41^{b,C}	-1.61±0.08^{b,C}	14.51±2.65	15.03±2.02	13.40±1.62 ^{ab}	14.80±1.52
T3	53.10±2.13	50.13±1.86	52.94±2.39^{a}	51.93±1.79	-6.07±0.37^{ab,A}	-5.33±0.67^{A}	-2.60^{a}±0.79^{B}	-3.20±0.79^{a,B}	15.65±1.53	12.95±2.84	14.38±0.93 ^{ab}	14.70±0.80
T4	49.92±2.04	48.65±1.67	51.62±1.27^{ab}	48.77±3.17	-5.48±1.30^{ab,A}	-4.28±0.74^{AB}	-2.41±0.45^{a,B}	-2.50±0.35^{ab,B}	13.71±2.06	11.68±4.91	13.38±0.94^{ab}	12.33±0.79
T5	51.38±2.18	49.06±1.94	49.23±1.28^{b}	50.66±1.29	-3.95±0.28^{b,AB}	-4.90±1.01^{A}	-2.17±0.27 ^{ab,B}	-2.90±0.22^{a,B}	12.67±1.18	13.92±3.12	12.95±0.94	15.07±1.76
F-test (Column wise)	ns	ns	*	ns	*	ns	*	ns	ns	ns	*	ns
Tukey (0.05)	4.84	4.86	3.54	5.16	2.32	1.59	1.28	0.99	4.67	7.39	2.70	3.29
% CV	4.25	3.93	4.11	4.27	17.49	14.55	25.80	17.57	16.14	21.39	10.86	11.39

Note: Values are presented as mean ± standard deviation (SD).

T1 = Control; T2 = 0.175% H_2O_2; T3 = 0.175% H_2O_2 + 0.03% 1-MCP; T4 = 0.175% H_2O_2 + 0.06% 1-MCP; T5 = 0.175% H_2O_2 + 0.09% 1-MCP.

Different letters (a–c) within the same column indicate significant differences among treatments at the same storage day ($p \leq 0.05$). Different letters (A–C) within the same row indicate significant differences across storage times within each treatment ($p \leq 0.05$). The absence of letters indicates no significant differences were found in that comparison, either among treatments (column-wise) or across storage times (row-wise). 'ns' denotes no significant difference according to the F-test. Tukey's HSD was used for mean separation when the F-test indicated significance.

Table 3 Effect of postharvest treatments on the flesh color values (L*, a*, b*) of 'Thongprasert' jackfruit during 20 days of storage at 13±1 °C.

Treatment	L*				a*				b*			
	Day 5	**Day 10**	**Day15**	**Day20**	**Day 5**	**Day 10**	**Day15**	**Day20**	**Day 5**	**Day 10**	**Day15**	**Day20**
T1	81.92±0.90	80.47±0.41	82.03±3.73	80.15±2.62	-0.86±0.33^{b,C}	2.83±0.65^{a,B}	2.73±0.88^{bc,B}	10.87±0.80^{A}	34.34±0.58^{dC}	40.85±0.35^{aB}	35.65±2.54^{cBC}	39.79±2.06^{bAB}
T2	81.00±1.01^{AB}	82.75±2.04^{A}	70.75±2.22^{bC}	77.65±2.03^{AB}	-0.91±0.32^{b,B}	0.87±0.16^{bc,B}	7.93±1.54^{a,A}	10.38±1.75^{A}	38.78±0.87^{bcd}	38.06±0.67^{bc}	38.94±3.04^{b}	37.06±2.14^{b}
T3	81.38±2.68	81.23±3.79	80.93±2.95^{a}	78.72±2.38	-0.73±0.33^{b,C}	0.25±0.14^{c,C}	4.52±1.43^{bc,B}	10.37±2.28^{A}	39.94±2.62^{bc}	38.51±3.47^{bc}	35.42±2.07^{c}	35.60±2.29^{b}
T4	80.63±2.21	81.18±2.86	77.97±4.69^{ab}	74.82±4.14	-0.85±0.12^{b,C}	0.91±0.29^{bc,C}	5.21±1.08^{ab,B}	12.27±1.88^{A}	42.66±1.51^{aA}	35.57±1.36^{cB}	41.45±2.07^{aA}	39.85±0.84^{abA}
T5	81.33±1.41	78.71±1.60	81.20±3.39^{a}	77.36±1.69	0.14±0.05^{a,C}	2.23±1.17^{ab,C}	2.01±1.14^{c,B}	11.83±0.21^{A}	38.32±0.95^{cd}	40.29±1.27^{ab}	40.38±1.59^{a}	41.49±2.56^{a}
F-test (column wise)	ns	ns	*	ns	*	*	*	ns	*	*	*	*
Tukey (0.05)	2.34	4.85	7.81	4.15	0.61	1.47	2.68	3.75	3.54	4.25	5.50	4.90
% CV	1.37	2.86	4.74	2.54	72.54	78.96	52.45	13.94	7.74	6.35	8.34	7.25

Note: Values are presented as mean ± standard deviation (SD).

T1 = Control; T2 = 0.175% H_2O_2; T3 = 0.175% H_2O_2 + 0.03% 1-MCP; T4 = 0.175% H_2O_2 + 0.06% 1-MCP; T5 = 0.175% H_2O_2 + 0.09% 1-MCP.

Different letters (a–c) within the same column indicate significant differences among treatments at the same storage day ($p \leq 0.05$).

Different letters (A–C) within the same row indicate significant differences across storage times within each treatment ($p \leq 0.05$).

The absence of letters indicates no significant differences were found in that comparison, either among treatments (column-wise) or across storage times (row-wise). 'ns' denotes no significant difference according to the F-test. Tukey's HSD was used for mean separation when the F-test indicated significance.

4.3 Changes in jackfruit Flesh Color

Table 3 illustrates the progression of flesh color changes during 20 days of storage at 13 ± 1°C. While L* values remained relatively stable in most treatments, T2 (0.175% H_2O_2) exhibited a significant decrease at day 15 ($p \leq 0.05$), suggesting treatment-related variation in internal flesh lightness over time. This indicates that the brightness of jackfruit flesh was largely preserved during the 20-day storage period, regardless of treatment. For the a* values, slight fluctuations were observed across storage days, particularly an increasing trend from day 5 to day 15, suggesting a gradual reduction in green intensity, reflected by higher a* values. However, no consistent or significant time-dependent pattern was identified across treatments, indicating a minimal effect of storage time on red-green balance of the flesh color. The b* values varied across treatments and storage times, with significant differences observed among treatments ($p \leq 0.05$). While yellowing progressed in all samples, the control group exhibited a stronger increase in b* values, indicating a greater conversion of chlorophyll to carotenoids. In contrast, jackfruits treated with 0.175% H_2O_2 combined with 1-MCP exhibited a slower increase in b* values. This suggests that 1-MCP suppressed ethylene-mediated chlorophyll degradation, while the antimicrobial action of H_2O_2 may have limited oxidative stress and associated enzymatic activity, such as chlorophyllase and peroxidases, which contribute to yellowing. This reflects the role of 1-MCP in delaying ripening by inhibiting ethylene action (Wasala et al., 2024).

4.4 Flesh Firmness

Jackfruit firmness, shown in Table 4, decreased over storage time in the control and less effective treatments, reflecting normal fruit softening during ripening. However, fruits treated with 0.175% H_2O_2 + 0.09% 1-MCP consistently maintained higher firmness compared to the control on all storage days ($p \leq 0.05$). Notably, this treatment showed no significant firmness loss across storage days, indicating effective suppression of softening and improved textural stability during storage. This finding is consistent with the study by Qiuping, & Wenshui (2007), who reported that both 1-MCP and chitosan helped maintain firmness and delay ripening in Xinjiang jujube. While 1-MCP functions by competitively inhibiting ethylene receptors and delaying ethylene-induced softening, chitosan forms a semi-permeable coating that reduces gas exchange and moisture loss, thereby slowing metabolic activity. The firmness retention observed in our study further supports the role of 1-MCP in inhibiting cell wall-degrading enzymes, such as polygalacturonase and cellulase, consistent with the findings of Zheng et al., (2023).

4.5 Total Soluble Solids (TSS)

While TSS values (measured as °Brix) naturally increase during storage due to ripening and dehydration, this reflects the conversion of starch into sugars, contributing to fruit sweetness (Zhang et al., 2024). A gradual increase indicates normal maturation, whereas a rapid rise suggests accelerated ripening and moisture loss, resulting in reduced shelf life. Based on Table 5, treatments that maintain a moderate increase in total soluble solids are desirable for preserving jackfruit quality while delaying overripening. Treatments with H_2O_2 and 1-MCP effectively moderated this change. Among all treatments, 0.175% H_2O_2 + 0.09% 1-MCP was the most effective in delaying the increase in total soluble solids, indicating superior performance in extending jackfruit shelf life by slowing ripening and reducing moisture loss. Similar patterns were observed in sugar apples treated with 1-MCP by Iwanami et al., (2024), where TSS increased moderately over time.

4.6 Disease Incidence

Disease incidence (Table 6) in jackfruit increased progressively during storage, particularly in the untreated control group, which rose from 1.15% on day 5 to 3.98% on day 15. This reflects typical postharvest microbial spoilage associated with ripening and senescence. Treatments with 0.175% H_2O_2 reduced disease incidence compared to the control at all storage times, confirming the antimicrobial properties of H_2O_2. The combination of 0.175% H_2O_2 with 1-MCP (0.03%, 0.06%, and 0.09%) further enhanced disease control. Importantly, there were no significant differences among the three 1-MCP concentrations on days 10, 15, and 20, indicating that all three combinations were similarly effective in suppressing disease progression during storage. The ability of 1-MCP to inhibit ethylene action likely contributed to delayed senescence and reduced susceptibility to microbial infection, consistent with Ali et al., (2023), who demonstrated microbial reduction in maize using H_2O_2, and Uprarawanna et al., (2021), who reported antimicrobial effects of 1-MCP and chitosan on stored mulberry caviar.

Overall, the combination of H_2O_2 with 1-MCP effectively reduced disease incidence compared to untreated fruit, with no additional benefit observed from increasing the 1-MCP concentration beyond 0.03% under these conditions.

Table 4 Effect of postharvest treatments on jackfruit flesh firmness during 20 days of storage at13±1°C

Treatment	Firmness			
	Day 5	Day 10	Day15	Day 20
T1	119.89±2.58^{b,A}	110.33±3.04^{ab,B}	99.30±3.62^{bc,C}	99.54±0.64^{d,C}
T2	128.96±2.78^{a,A}	103.96±2.87^{b,B}	94.88±3.46^{c,C}	104.21±0.67^{c,B}
T3	120.14±2.59^{b,A}	112.78±3.11^{a,AB}	104.45±3.81^{bc,C}	114.25±0.73^{a,AB}
T4	117.44±2.53^{b,A}	111.31±3.07^{ab,AB}	109.60±3.99^{ab,C}	112.29±0.72^{b,AB}
T5	119.65±2.58^{b}	118.18±3.26^{a}	116.71±4.25^{a}	114.50±0.74^{a}
F-test	*	*	*	*
Tukey (0.05)	6.19	7.28	9.48	3.53
% C.V.	3.86	4.85	8.74	1.54

Note: Values are presented as mean ± standard deviation (SD)
T1 = Control; T2 = 0.175% H_2O_2; T3 = 0.175% H_2O_2 + 0.03% 1-MCP; T4 = 0.175% H_2O_2 + 0.06% 1-MCP; T5 = 0.175% H_2O_2 + 0.09% 1-MCP
Different letters (a–c) within the same column indicate significant differences among treatments at the same storage day ($p \leq 0.05$)
Different letters (A–C) within the same row indicate significant differences across storage times within each treatment ($p \leq 0.05$)
Tukey's HSD was used for mean separation when the F-test indicated significance

Table 5 Effect of postharvest treatments on the total soluble solid content (°Brix) of 'Thongprasert' jackfruit flesh during 20 days of storage at 13±1°C

Treatment	Total Soluble Solid			
	Day 5	Day 10	Day 15	Day 20
T1	3.30±0.20^{ab,C}	4.20±0.51^{BC}	5.00±0.60^{bc,B}	8.70±0.44^{ab,A}
T2	3.50±0.21^{ab,B}	4.50±0.55^{B}	8.00±0.96^{a,A}	9.30±0.47^{a,A}
T3	3.80±0.23^{a,C}	4.05±0.49^{BC}	5.00±0.60^{bc,B}	7.90±0.40^{bc,A}
T4	3.20±0.19^{b,C}	3.60±0.44^{C}	5.20±0.62^{b,B}	7.50±0.38^{c,A}
T5	2.50±0.15^{c,C}	3.40±0.41^{B}	3.40±0.41^{c,B}	5.80±0.29^{d,A}
F-test (column-wise)	*	ns	*	*
Tukey (0.05)	0.53	1.29	1.77	1.08
% C.V.	14.63	14.69	30.81	12.16

Note: Values are presented as mean ± standard deviation (SD)
T1 = Control; T2 = 0.175% H_2O_2; T3 = 0.175% H_2O_2 + 0.03% 1-MCP; T4 = 0.175% H_2O_2 + 0.06% 1-MCP; T5 = 0.175% H_2O_2 + 0.09% 1-MCP
Different letters (a–c) within the same column indicate significant differences among treatments at the same storage day ($p \leq 0.05$)
Different letters (A–C) within the same row indicate significant differences across storage times within each treatment ($p \leq 0.05$)
'ns' denotes no significant difference according to the F-test. Tukey's HSD was used for mean separation when the F-test indicated significance

Table 6 Effect of postharvest treatments on disease incidence (%) of 'Thongprasert' jackfruit during 20 days of storage at 13±1 °C

Treatment	Disease Incidence			
	Day 5	Day 10	Day15	Day20
T1	1.15±0.12^{a,B}	3.28±0.17^{a,A}	3.98±0.45^{a,A}	3.74±0.40^{a,A}
T2	0.92±0.10^{ab,B}	1.65±0.09^{b,A}	1.90±0.22^{b,A}	1.66±0.18^{b,A}
T3	0.85±0.09^{b,B}	1.01±0.05^{c,B}	0.87±0.10^{c,B}	1.40±0.15^{b,A}
T4	0.64±0.07^{b,C}	0.97±0.05^{c,B}	1.07±0.12^{c,B}	1.76±0.19^{b,A}
T5	1.20±0.13^{a,B}	0.94±0.05^{c,B}	1.06±0.12^{c,B}	1.95±0.21^{b,A}
F-test	*	*	*	*
Tukey (0.05)	0.25	0.23	0.58	0.57
% C.V.	24.11	59.20	71.00	68.28

Note: Values are presented as mean ± standard deviation (SD)
T1 = Control; T2 = 0.175% H_2O_2; T3 = 0.175% H_2O_2 + 0.03% 1-MCP; T4 = 0.175% H_2O_2 + 0.06% 1-MCP; T5 = 0.175% H_2O_2 + 0.09% 1-MCP
Different letters (a–c) within the same column indicate significant differences among treatments at the same storage day ($p \leq 0.05$)
Different letters (A–C) within the same row indicate significant differences across storage times within each treatment ($p \leq 0.05$)
'ns' denotes no significant difference according to the F-test. Tukey's HSD was used for mean separation when the F-test indicated significance

4.7 Visual Appearance of Jackfruit Samples during Storage

Figure 1 illustrates the visual changes in 'Thongprasert' jackfruit subjected to different postharvest treatments during storage at 13 ± 1°C for 20 days. Across the storage period, progressive alterations in peel color, surface texture, and visible disease symptoms were observed, with notable differences among treatments.

In the control group, jackfruits exhibited a clear ripening progression, characterized by significant peel yellowing and surface deterioration. By day 10, noticeable yellowing appeared, along with slight browning and textural softening. By day 15, fruits showed extensive yellow coloration covering most of the peel surface, along with visible browning, surface shriveling, and occasional decay spots. By day 20, the control fruits displayed advanced ripening symptoms with pronounced peel browning, softening, and widespread disease incidence, visually supporting data from colorimetric and disease incidence measurements.

Fruits treated with 0.175% H_2O_2 alone exhibited a delayed onset of visual ripening symptoms compared to the control. On day 10, the yellowing was less intense, and the surface texture remained firmer, with fewer blemishes. However, by day 15, yellowing became evident, though it was slightly less severe than in control fruits. Disease symptoms such as surface lesions and decay spots appeared but were less extensive. By day 20, the treated fruits still showed notable yellowing and browning; however, the degree of deterioration was visibly reduced compared to the untreated samples. This confirms the moderate effectiveness of H_2O_2 in delaying ripening and suppressing microbial spoilage.

Combining H_2O_2 with 1-MCP at 0.03% further enhanced the preservation of visual quality. At day 10, fruits retained a greener peel with only mild yellow patches, and the surface texture appeared firm and smooth. By day 15, yellowing was present but limited, and disease symptoms were minimal. At day 20, fruits exhibited moderate yellowing but maintained a relatively intact surface appearance with fewer signs of decay compared to the control and H_2O_2-only treatments. This visual observation correlates with data showing reduced weight loss, delayed color change, and lower disease incidence.

The treatment with 0.175% H_2O_2 + 0.06% 1-MCP demonstrated even better preservation effects. Throughout the storage period, fruits maintained a greener peel color for a longer duration, with less pronounced yellowing even on day 15. Disease symptoms such as surface spots and lesions appeared minimally. By day 20, fruits showed delayed peel yellowing and maintained a fresher appearance, supporting the quantitative data that demonstrated better firmness and lower disease incidence.

Interestingly, the 0.175% H_2O_2 + 0.09% 1-MCP treatment, while effective in slowing overall peel yellowing, did not exhibit clear visual superiority over the 0.06% treatment. By day 20, fruits treated with 0.09% 1-MCP exhibited similar levels of yellowing and surface browning as those treated with 0.06%, showing only slight visual differences. This aligns with the lack of significant difference in measured parameters (color, disease incidence) between these two treatments, suggesting no added visual benefit from increasing the 1-MCP concentration beyond 0.06% under these storage conditions.

Overall, the visual observations confirm that postharvest treatments combining H_2O_2 and 1-MCP effectively delayed peel yellowing and reduced visible spoilage symptoms during storage. Among the treatments, 0.175% H_2O_2 + 0.06% 1-MCP maintained the highest visual quality by day 20, as evidenced by reduced browning and minimal peel cracking, providing a balanced effect on ripening delay and disease suppression. Although the 0.09% 1-MCP treatment (T5) also improved quality, its visual appearance by day 20 was not significantly superior to that of the 0.06% treatment.

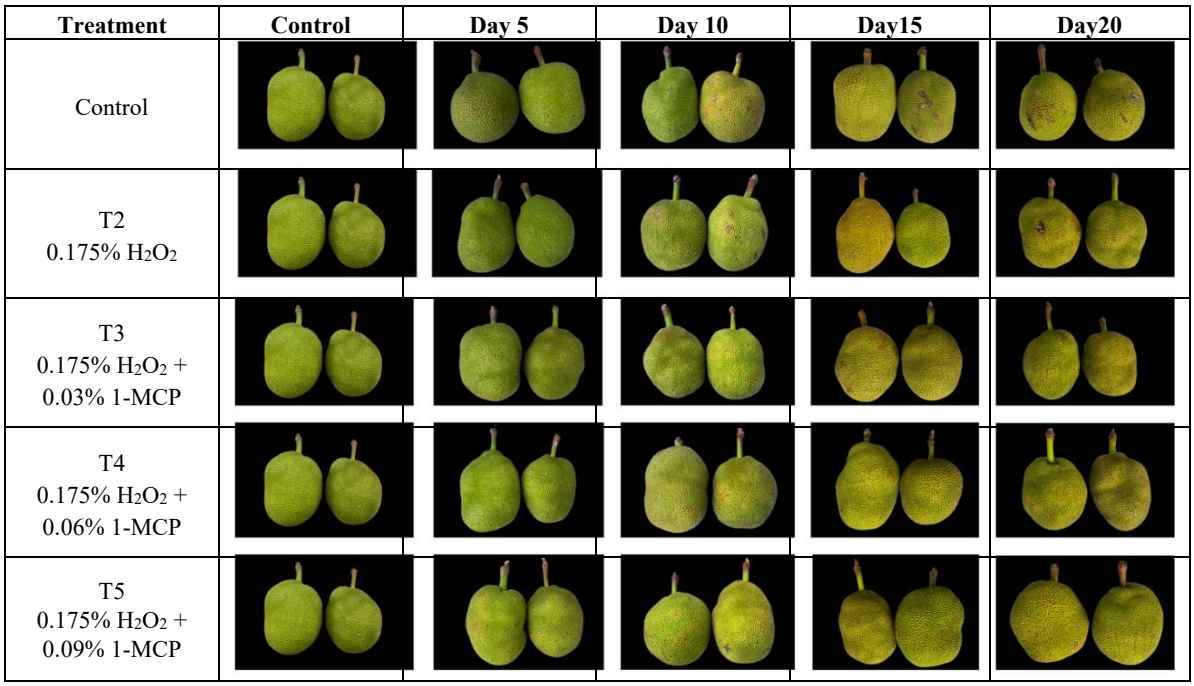

Figure 1 Visual appearance of 'Thongprasert' jackfruit samples under different postharvest treatments during storage at 13 ± 1°C for 20 days. Treatments included Control (untreated), 0.175% H_2O_2, and combinations of 0.175% H_2O_2 with 0.03%, 0.06%, and 0.09% 1-MCP. Images represent randomized samples on days 5, 10, 15, and 20, illustrating general changes in peel color, surface texture, and disease incidence

4.8 Summarized Discussion for Selection of the Best Treatment

A comprehensive evaluation of postharvest quality parameters revealed that the combination of 0.175% hydrogen peroxide (H_2O_2) with 0.06% 1-MCP provided the most effective results in preserving quality and extending the shelf life of 'Thongprasert' jackfruit. Although the 0.09% 1-MCP treatment (T5) exhibited slightly lower weight loss and a slower increase in TSS compared to the 0.06% 1-MCP treatment (T4), the differences were not statistically significant ($p > 0.05$). Therefore, both concentrations can be considered similarly effective under the tested conditions. Across multiple parameters weight loss reduction, peel and flesh color stability, firmness retention, moderated TSS accumulation, and suppression of disease incidence the combination of 0.175% H_2O_2 with 0.06% 1-MCP consistently showed superior performance. Visual assessments further confirmed that increasing the 1-MCP concentration beyond 0.06% did not result in visibly better fruit quality. Considering the lack of significant improvements with higher concentrations and the economic efficiency of using lower 1-MCP levels, the treatment combining 0.175% H_2O_2 with 0.06% 1-MCP is concluded to be the optimum postharvest strategy for maintaining 'Thongprasert' jackfruit quality during storage at 13 ± 1°C.

5. Conclusion

This study demonstrated that postharvest treatment with 0.175% hydrogen peroxide (H_2O_2) combined with 1-methylcyclopropene (1-MCP) effectively delayed ripening, reduced weight loss, maintained peel and flesh color, preserved firmness, controlled disease incidence, and moderated total soluble solids accumulation in 'Thongprasert' jackfruit during 20 days of cold storage. Among the tested concentrations, 0.06% 1-MCP combined with H_2O_2 was identified as the optimum treatment, providing a balanced effect across all quality parameters without requiring higher chemical input. Increasing 1-MCP to 0.09% did not yield additional benefits. Therefore, the combination of 0.175% H_2O_2 + 0.06% 1-MCP is recommended as a practical and cost-effective postharvest strategy for extending shelf life and preserving the market quality of 'Thongprasert' jackfruit.

5.1 Limitations and Future Work

This study demonstrated the effectiveness of 0.175% H_2O_2 + 0.06% 1-MCP in preserving the

quality of 'Thongprasert' jackfruit during cold storage. However, several limitations should be considered. The experiment was conducted under controlled laboratory conditions (13± 1°C), which may not reflect real-world fluctuations in temperature and humidity during transportation and retail. Additionally, the study focused on physical and external quality attributes, while important aspects such as sensory properties and nutritional quality were not evaluated.

The research was also limited to a single jackfruit cultivar, which may not reflect the responses of other varieties. Future studies should therefore assess the effectiveness of these treatments on different jackfruit cultivars and consider commercial-scale trials. Exploring combinations with natural coatings or bioactive compounds could further enhance shelf life while reducing chemical usage.

6. Acknowledgements

The authors gratefully acknowledge AA Farm, Prachuap Khiri Khan Province, for providing the jackfruit samples used in this study, which was conducted at the request of the farm owner.

7. CRediT Statement

Tanatya Kenkhunthot: Conceptualization, methodology, writing – original draft, validation.
Kasideth Onsri: Formal analysis, visualization, writing & editing.
Bunnavit Nathaweesap: Investigation, resources, data curation, software.

8. References

Abdelshafy, A. M., Hu, Q., Luo, Z., Ban, Z., & Li, L. (2024). Hydrogen peroxide from traditional sanitizer to promising disinfection agent in food industry. *Food Reviews International*, *40*(2), 658-690. https://doi.org/10.1080/87559129.2023.2191690

Ahmad, A., Hashmi, M. S., Durrani, Y., Khan, N. A., Khan, M. R., Siddiqi, M. Z., ... & Rahman, W. U. (2023). Synergy of 1-MCP and hypobaric treatments prevent fermented flavour and improve consumers' acceptability of 'Shughri'pear. *Journal of Food Science and Technology*, *60*(1), 200-210. https://doi.org/10.1007/s13197-022-05605-y

Ali, B., Hafeez, A., Afridi, M. S., Javed, M. A., Sumaira, Suleman, F., ... & Darwish, D. B. E. (2023). Bacterial-mediated salinity stress tolerance in maize (Zea mays L.): a fortunate way toward sustainable agriculture. *ACS omega*, *8*(23), 20471-20487. https://doi.org/10.1021/acsomega.3c00723

Arista, N. I. D., & Ardiningtyas, S. A. (2024). Comparative analysis of ethylene-induced ripening in climacteric and non-climacteric fruits: implications for post-harvest management. *Social Agriculture, Food System, and Environmental Sustainability*, *1*(2), 90-100. https://doi.org/10.61511/safses.v1i2.2024.1202

Booth, S., & Altomara, D. (2024). *Health benefits of jackfruit*. WebMD. Retrieved from https://www.webmd.com/food-recipes/health-benefits-jackfruit

Burana, C. (2018). Effect of pe-cooling treatment, 1-methylcyclopropene (1-MCP) and controlled atmosphere (CA) on vase life of cut spray carnation flowers. *International Scientific Journal of Engineering and Technology (ISJET)*, *2*(2), 33-37.

de Siqueira Oliveira, L., Eça, K. S., de Aquino, A. C., & Vasconcelos, L. B. (2018). Hydrogen peroxide (H2O2) for postharvest fruit and vegetable disinfection. *Postharvest Disinfection of Fruits and Vegetables*, 91-99. https://doi.org/10.1016/B978-0-12-812698-1.00004-2

Fagundes, C., Carciofi, B. A. M., & Monteiro, A. R. (2013). Estimate of respiration rate and physicochemical changes of fresh-cut apples stored under different temperatures. *Food Science and Technology*, *33*(1), 60-67. https://doi.org/10.1590/S0101-20612013005000023

Hewitt, S., & Dhingra, A. (2020). Beyond ethylene: new insights regarding the role of alternative oxidase in the respiratory climacteric. *Frontiers in Plant Science*, *11*, Article 543958. https://doi.org/10.3389/fpls.2020.543958

Iwanami, H., Moriya-Tanaka, Y., Hanada, T., Baba, T., & Sakamoto, D. (2024). Factors explaining variations in soluble solids content of apples during ripening and storage. *The Horticulture Journal*, *93*(2), 135-142. https://doi.org/10.2503/hortj.QH-105

Kaur, J., Singh, Z., Shah, H. M. S., Mazhar, M. S., Hasan, M. U., & Woodward, A. (2024). Insights into phytonutrient profile and postharvest quality management of jackfruit: A review. *Critical Reviews in Food Science*

and Nutrition, *64*(19), 6756-6782. https://doi.org/10.1080/10408398.2023.2174947

Meng, X., Huang, Z., & Fan, C. (2019). Postharvest treatment with hydrogen peroxide to control orange fruit decay caused by *Penicillum digitatum* and *Penicillum italicum. International Journal of Applied Agricultural Sciences*, *5*(5), 114-119. https://doi.org/10.11648/j.ijaas.20190505.13

Morelos-Flores, D. A., Chacón-López, M. A., Montalvo-González, E., de Lourdes García-Magaña, M., Nolasco-González, Y., Hernández-Fuentes, L. M., & González-Hernández, H. (2023). Effect of 1-methylcyclopropene on jackfruit with marketing simulation at 8°C. *Emirates Journal of Food and Agriculture*, *35*(10), 906-917. https://doi.org/10.9755/EJFA.2023.3150

Onsrisawat, P., Rodthong, S., Yahuafai, J., & Urairong, H. (2022). Hepatoprotective and antioxidant properties of *Schizophyllum commune* fruiting body. *Journal of Current Science and Technology, 12*(3), 615–628. https://doi.org/10.14456/jcst.2022.47

Osiripun, V., & Labua, S. (2023). Effects of thermal processing on cannabidiol degradation in cannabidiol-infused pomegranate juice and evaluation of its antioxidant property. *Journal of Current Science and Technology, 13*(1), 107–117. https://doi.org/10.14456/jcst.2023.10

Pathare, P. B., Opara, U. L., & Al-Said, F. A. J. (2013). Colour measurement and analysis in fresh and processed foods: A review. *Food and Bioprocess Technology*, *6*(1), 36-60. https://doi.org/10.1007/s11947-012-0867-9

Plainsirichai, M., Trinok, U., & Turner, D. W. (2010). 1-methylcyclopropene (1-MCP) reduces water loss and extends shelf life of fruits of Rose apple (Syzygium jambos Alston) cv. TabtimChan. *Fruits*, *65*(3), 133-140. https://doi.org/10.1051/fruits/2010008

Pomasa, P., Sai-Ut, S., Sinthusamran, S., & Techavuthiporn, C. (2024). Formulation of supplemented thai custard spread using jackfruit rag and sugar replacement with stevia. *Current Applied Science and Technology*, *24*(4), e0259802-e0259802. https://doi.org/10.55003/cast.2024.259802

Pragalyaashree, M. M., Monikca, A., Blessie, F., & Deivanayagame, T. (2023). Jackfruit processing and utilization of its waste: A review. *Asia-Pacific Journal of Science and Technology*, *28*(04), 1-10. https://doi.org/10.14456/apst.2023.57

Puangwerakul, Y., Chaisakdanukul, C., Soithongsuk, S., Sajjaut, S., & Pewlong, W. (2024). Comparative effects of HPP and irradiation on plant-based whole hard-boiled eggs. *Journal of Current Science and Technology*, *14*(3), Article 66. https://doi.org/10.59796/jcst.V14N3.2024.66

Qiuping, Z., & Wenshui, X. (2007). Effect of 1-methylcyclopropene and/or chitosan coating treatments on storage life and quality maintenance of Indian jujube fruit. *LWT-Food Science and Technology*, *40*(3), 404-411. https://doi.org/10.1016/j.lwt.2006.01.003

Ranasinghe, R. A. S. N., Maduwanthi, S. D. T., & Marapana, R. A. U. J. (2019). Nutritional and health benefits of jackfruit (Artocarpus heterophyllus Lam.): A review. *International Journal of Food Science*, *2019*(1), Article 4327183. https://doi.org/10.1155/2019/4327183

Rattanapakdee, R., Thobunluepop, P., Anusonpornperm, S., Chaisan, T., Pongtip, A., Maniin, P., Chitbanchong, W., & Gorinstein, S. (2024). Effects of harvest time on medicinal qualities of hemp. *Journal of Current Science and Technology, 14*(3), Article 63. https://doi.org/10.59796/jcst.V14N3.2024.63

Sahoo, S. K., Tomar, M. S., & Pradhan, R. C. (2021). Disinfecting agents for controlling fruits and vegetable diseases after harvest. *Food Losses, Sustainable Postharvest and Food Technologies*, 103-151. https://doi.org/10.1016/B978-0-12-821912-6.00007-9

Taikerd, T., & Leelawat, B. (2023). Effect of young jackfruit, wheat gluten and soy protein isolate on physicochemical properties of chicken meat analogs. *Agriculture and Natural Resources*, *57*(2), 201-210. Retrieved from https://li01.tci-thaijo.org/index.php/anres/article/view/259076

Tridge. (2023). *Export Trends Overview of Top 10 Countries in 2023*. Retrieved from https://www.tridge.com/intelligences/jackfruit/export

Tridge. (2025). *Export market for Fresh Jackfruit in Thailand*. Retrieved from https://www.tridge.com/intelligences/jackfruit/TH

Uprarawanna, U., Jaimun, R., & Kanha, N. (2021). Effects of chitosan concentrations in the chitosan-alginate composite on the quality of mulberry caviar during storage. *Journal of Food Health and Bioenvironmental Science*, *14*(2), 34-46.

Wasala, W. M. C. B., Benaragama, C. K., Kumara, G. D. K., Sarananda, K. H., & Dissanayake, C. A. K. (2024). Effect of 1-methylecyclopropene and Low Temperature Storage on Postharvest Longevity of Banana cv 'Ambul'. *Journal of Agricultural Sciences–Sri Lanka*, *19*(3), 566-581. https://doi.org/10.4038/jas.v19i3.10385

Ying, J. C. L., Jaffar, N. S., Hussin, W. M. R. I. W., Hamid, M. F. A., & Muhsin, N. I. (2020). Maintaining postharvest quality of jackfruit during cold storage. *International Journal of Agriculture, Forestry and Plantation*, *10*, 282-286.

Zhang, J., Ma, Y., Dong, C., Terry, L. A., Watkins, C. B., Yu, Z., & Cheng, Z. M. M. (2020). Meta-analysis of the effects of 1-methylcyclopropene (1-MCP) treatment on climacteric fruit ripening. *Horticulture Research*, *7*, Article 208. https://doi.org/10.1038/s41438-020-00405-x

Zhang, S., Li, Y., Du, M., Li, X., Wang, J., Ban, Z., & Jiang, Y. (2024). Practical 1-Methylcyclopropene Technology for Increasing Apple (Malus domestica Borkh) Storability in the Aksu Region. *Foods*, *13*(18), Article 2918. https://doi.org/10.3390/foods13182918

Zheng, Y., Jia, X., Duan, L., Li, X., & Zhao, Z. (2023). Synergistic Effects of 1-MCP fumigation and ε-Poly-L-Lysine treatments on delaying softening and enhancing disease resistance of flat peach fruit. *Foods*, *12*(19), Article 3683.