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The Effect of Ascorbic Acid on the Quality of Fresh Cut Pineapple (*Ananas comosus* (L.) Merr) Stored at 5 °C

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Abstract

Fresh-cut pineapple is increasingly popular due to its convenience and high nutritional value. This study evaluated the effects of different concentrations of ascorbic acid on the quality of fresh-cut pineapple (Ananas comosus L. var. MS16) stored at 5 °C by analyzing hardness, color parameters (L*, a*, b*, chroma, hue angle), soluble solids content, sugar/acid ratio, ascorbic acid content, and total titratable acidity. Results showed that ascorbic acid had no significant effect ($p > 0.05$) on hardness and color, indicating stable texture and appearance, but significantly affected ($p < 0.05$) the sugar/acid ratio, ascorbic acid content, and total titratable acidity. The 0.5% treatment best maintained texture (3.02 N), acidity (4.56% citric acid), and color stability, while the 1% treatment produced the highest vitamin C content (28.53 mg/100 g). The control exhibited the highest sugar/acid ratio (40.89), indicating a sweeter taste but lower antioxidant protection. Overall, 0.5% ascorbic acid was the most effective concentration for preserving freshness and nutritional quality during cold storage.

Keywords: Ascorbic Acid, Cold Storage, Fresh Fruit, Pineapple, Quality Preservation

1. Introduction

Fresh-cut fruit is increasingly sought after by consumers due to its convenience, freshness, and nutritional value. Pineapple (Ananas comosus L. Merr.) is one of the most popular tropical fruits in the ready-to-eat market because of its unique aroma, sweet taste, and high vitamin C content. The cutting process, which includes peeling and core removal, exposes the fruit's internal tissues to oxygen and enzymatic reactions that accelerate physiological damage such as enzymatic browning, texture softening, loss of ascorbic acid, and microbial spoilage (Chen et al., 2024) .

Pineapple fruit damage is strongly influenced by abiotic factors arising from both internal physiological processes and external environmental conditions. Internal factors include metabolic activities such as respiration and enzyme reactions that regulate ripening and senescence, while external factors involve temperature fluctuations, mechanical stress, humidity, light exposure, and physical injury during handling. Elevated storage temperatures, in particular, accelerate respiration rates and metabolic activity, leading to faster substrate depletion, cellular breakdown, and overall quality deterioration. Increased respiration increases tissue degradation and shortens shelf life, contributing significantly to postharvest losses (Valenzuela, 2023) . As a result, enzymatic browning and rapid decrease in stiffness result in undesirable changes in appearance and texture (Djioua et al., 2009) . This browning is primarily related to the oxidation of phenolic compounds by the enzyme polyphenol oxidase (PPO), which produces brown quinone compounds. In addition, the degradation of ascorbic acid during storage also accelerates the oxidation reaction and color loss (Rojas-Graü et al., 2009) .

Damage to pineapple fruit caused by abiotic factors such as temperature fluctuations, mechanical injury, and increased respiration significantly affects physiological stability and postharvest quality. Exposure to inappropriate storage temperatures and physical damage disrupts cellular membranes and accelerates respiration and metabolic processes, leading to faster senescence. These physiological changes result in reduced nutritional value, deterioration of flavor and color, and increased susceptibility to microbial infection and decay. As a result, abiotic stress plays a major

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role in postharvest deterioration and reduces the marketable quality and quantity of pineapple fruit (Palumbo et al., 2022) . As a result, farmers and supply chain actors face significant economic losses, because damaged fruits are less appealing to consumers and often fetch lower market prices, while overall food availability also declines. Postharvest losses represent a substantial waste of resources, including labor, water, and farm inputs, with estimates that losses can reach up to 25–50% of harvested fruits and vegetables, especially in developing regions. These losses affect not only producers but also consumers, who may receive products with reduced nutritional value and shorter shelf life, thus impacting food security and economic welfare.

This quality loss limits the shelf life of minimally processed pineapple, making post-cut preservation methods crucial. Previous research has shown that one of the challenges faced by farmers is the limited shelf life and the deterioration of the physical and chemical properties of the fruit (Naibaho et al., 2025) . One widely used natural preservative is ascorbic acid, which functions as a natural antioxidant to delay oxidative browning and maintain the visual and nutritional quality of fresh-cut fruit products. Ascorbic acid acts as a reducing agent that inhibits the activity of polyphenol oxidase (PPO) and peroxidase (POD), two major enzymes responsible for the formation of brown pigments on the surface of cut fruit. In addition, soaking in ascorbic acid solution (0.5-2%) helps stabilize color and maintain sensory attributes during cold storage by converting quinones back to their native phenolic form, thus preventing pigment accumulation (Serrano et al., 2006) . In a study of fresh-cut pineapples, soaking in ascorbic acid solution (0.5-2%) was shown to significantly reduce surface browning, maintain sensory acceptability, and slow the loss of vitamin C (Djioua et al., 2009; Hong & Gross, 2001) .

Storage temperature plays a critical role in regulating biochemical activity and microbial growth in fresh-cut fruit. Temperature directly influences respiration rate, enzymatic reactions, and microbial proliferation, all of which determine post-cutting shelf life. In pineapple, improper temperature management accelerates metabolic processes and microbial spoilage, leading to rapid quality deterioration. Conversely, low-temperature storage effectively slows respiration and suppresses microbial growth, thereby extending shelf life and reducing postharvest losses (Valenzuela, 2023) . Research shows that storing cut pineapple at temperatures between 2-5 °C can slow enzymatic activity and microbial growth compared to storage at higher temperatures (Oms-Oliu et al., 2010) . Research shows that agricultural products stored at low (cold) temperatures will last longer than those stored at room temperature. The use of low temperatures for each type of fruit is different, but if the temperature is lower than the optimum temperature it can cause damage (chilling injury) (Breemer et al., 2024) .

An optimal balance between low temperature and antioxidant protection is essential for extending shelf life while maintaining product quality. The combination of antioxidant treatment and low-temperature storage has been proven to act synergistically in preserving the quality of fresh pineapple. Djioua et al. (2009) demonstrated that the application of ascorbic acid followed by storage at 4 °C was able to maintain firmness and prevent browning in fresh-cut pineapple. In addition, Oms-Oliu et al. (2010) reported that the combination of 1% ascorbic acid with cold storage inhibited microbial growth and preserved overall sensory quality.

Other studies also support the effectiveness of ascorbic acid in maintaining the quality of fresh-cut pineapple during cold storage. Hong & Gross (2001) also reported that ascorbic acid acts as a reducing agent that inhibits the activity of polyphenol oxidase (PPO), thereby preserving color and nutritional value in fresh-cut fruit. Meanwhile, Rojas-Graü et al. (2009) showed that the combination of antioxidant treatment and low temperature slowed the degradation of ascorbic acid and maintained the physicochemical quality of various fresh-cut fruits.

Although numerous studies have demonstrated the effectiveness of ascorbic acid in preserving the quality of fresh-cut fruit, most previous research has focused on storage at 4 °C, involved a variety of fruit types, or emphasized only one or two quality parameters. Therefore, the novelty of the present study lies in its comprehensive evaluation of the effects of ascorbic acid on multiple physicochemical and nutritional quality parameters of fresh-cut pineapple (Ananas comosus (L.) Merr .) stored specifically at 5 °C, which more closely reflects commercial storage conditions at the distribution and retail levels. This study also emphasizes the determination of the most effective ascorbic acid concentration for simultaneously maintaining texture, color, acidity, and vitamin C content, thereby providing practical recommendations for postharvest handling of fresh-cut pineapple.

2. Material and Methods

2.1. Research Location

This research was conducted at the Post-Harvest Complex, Horticultural Research Center, Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Selangor at coordinates 2.9911°N, 101.70160 E, 50 meters above sea level.

2.2. Experimental Design

This study was conducted to evaluate the effect of ascorbic acid treatment and storage temperature on the quality of fresh pineapple after cutting. The experimental design used was a completely randomized design (CRD) with two factors. Fresh pineapple samples were evaluated periodically during the storage period, namely on days 0, 4, 8, and 12.

2.3. Sample Provision

Ripe, uniform, and defect-free pineapples (Ananas comosus L. Merr ., cv. MS16) were obtained from local plantations. The fruits were washed with running tap water, sanitized using sodium hypochlorite solution (100 ppm) for 2 minutes, and air-dried. The fruits were then manually peeled, seeded, and cut into uniform cubes measuring approximately 2.5 x 2.5 x 2.5 cm using a sterile stainless steel knife. The cutting process was carried out under clean conditions at a temperature of 10 ± 2°C to minimize enzymatic activity.

2.4. Ascorbic acid treatment

Sliced pineapple samples were immersed in 0.5% and 1% (w/v) ascorbic acid solution for 1 minute. The solutions were prepared using food-grade L-ascorbic acid dissolved in cold, filtered water. Control samples were immersed in a 0.5% NaCl + 0.5% CaCl2 solution for the same period. After immersion, excess solution was carefully drained before packaging.

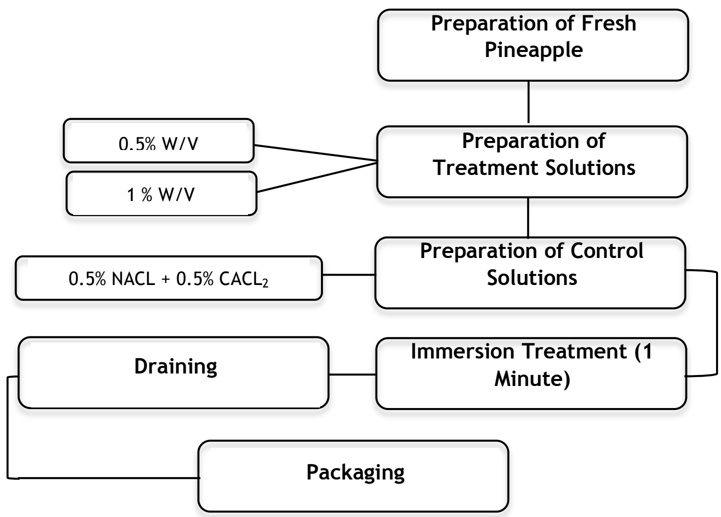

Figure 1. Visual appearance of fresh-cut pineapple treated with ascorbic acid during storage at 5 °C.

2.5. Packaging and Storage Conditions

Approximately 150 g of processed pineapple pieces were placed in polyethylene terephthalate (PET) containers that were tightly closed to prevent air ingress. All containers were stored at 5 °C for 12 days. Samples were analyzed every 4 days (Days 0, 4, 8, and 12) to assess physicochemical quality parameters.

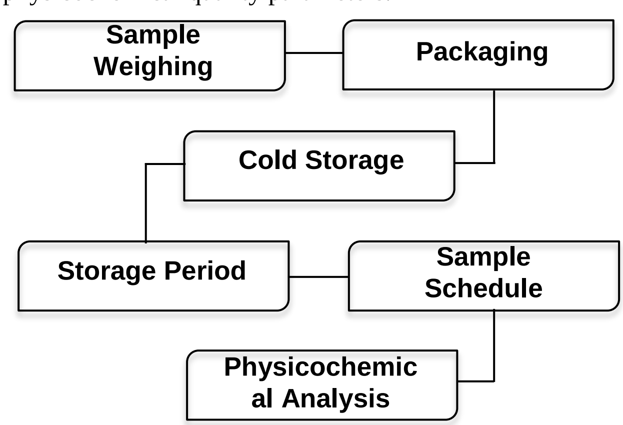

Figure 2. Flow Diagram of Packaging and Storage Conditions

2.6. Color Measurement

Changes in the color of the skin and flesh of the fruit were determined based on the brightness (L*), hue (H) and chroma (C*) parameters which were evaluated individually on each fruit for each treatment with 3 replications with each replication consisting of 3 fruit cubes. Parameter measurements were based on the 55 CIE Lab System using a Chromameter model Minolta CR300 (Minolta Camera Co., Japan).

2.7. Stiffness Measurement

Fruit firmness was measured using a Texture Analyzer, TA-XT Plus (Stable Micro Systems, England) connected to a computer. Each treatment was replicated three times with three fruit cubes. The total force required by the needle to penetrate the mesocaps was read by the machine. The machine was set at a maximum pressure of 20 mm/min using a 0.5 mm diameter crosshead. Compressive strength was measured at the maximum peak recorded on the strength graph and converted to Newtons (N). Three strength (N) readings of the fruit tissue in each treatment were recorded.

2.8. Total Dissolved Solids (TSS)

Fruit from each treatment was ground using a blender without water for 3 minutes at medium speed. Analysis was carried out immediately to obtain total soluble solids. The fruit juice obtained from the grinding results was measured using a Digital Refractometer (Model: DBX-55) from Atago Co. Ltd., Tokyo, Japan. Before the measurement was carried out, the refractometer was calibrated first using distilled water to obtain a result of 0%. The readings were taken at room temperature and the results were interpreted in % (°Brix).

2.9. Determination of Ascorbic Acid (Vitamin C) Content

Ascorbic acid was determined using the dye method (Ranggana , 1977). A 10g sample of the ground sample was mixed with 90 ml of metaphosphoric acid (HPO_3) at a concentration of 3%. The sample volume is titrated using a dye solution (2, 6-dichlorophenol indophenol) until the solution turns bright pink, lasting for 15 seconds before turning clear. The ascorbic acid content was calculated based on:

Vitamin C (mg/100g) [Titration value (ml) x Dye factor x added volume (ml) x 100] /[sample volume (ml) x Sample weight (g)] was set to 100 mL. A 5 mL sample was The dye factor calculation is based on the following: 5 mL of standard ascorbic acid and 5 mL of 3% HPO_3 are mixed. This mixture is titrated with the dye solution until it turns bright pink. The dye factor is calculated based on:

Dye factor = µg ascorbic acid/Dye titration value (ml)Statistical Analysis

2.10. Measurement of pH Value and Titrated Acid Content (KT)

The pH value was determined using an automatic pH meter (WTW Microprocessor pH 539 meter , Germany). The pH meter was then calibrated using pH buffers at pH 4.0 and 7.0 before use. After the electrode needle was inserted into the fruit juice solution, a stable pH reading was recorded. The titrated acidity was analyzed using the titration method by Ranggana (1977). A 5g sample of mashed fruit was mixed with 20 mL of distilled water. The solution was titrated with 0.1 N sodium hydroxide (NaOH) to an endpoint of pH 8.1. The titration value was recorded and the result was interpreted as the percentage of citric acid based on the following calculation:

Total Acidity (%) = [Titration value (ml) x Normality of NaOH (0.1N) x Amount made (ml) x equivalent weight of citric acid (64g) x 100]/ [Sample weight x 100]

2.11. Sugar-Acid Ratio

Sugar-acid content can be calculated by dividing the total dissolved solids by the total titrated acid to obtain the sugar-acid ratio. This ratio provides a good idea of the balance between sweetness and acidity in pineapple.

2.12. Statistical Analysis

The software used in this analysis was SPSS version 20.0, with treatment responses analyzed statistically using Analysis of Variance (ANOVA). For comparisons of more than two means, separation of means was performed using Duncan's Multiple Range Test (SAS Inst. 1985). This test determines whether the comparison between treatments and storage periods shows a significant difference ($p<0.05$). The average results are presented in tables and figures. The experimental data are presented as the average and standard deviation for each sample.

3. Results and Discussion

Table 1 shows the hardness values and color parameters (L, a, b*) of fresh-cut pineapple treated with various concentrations of ascorbic acid and stored at 5 °C. Data are presented as mean ± standard error (SE) at a 97% confidence level.* *

Table 1. Firmness (N), color (L, a, b,) of fresh pineapple slices stored at 5 °C

Factor	Stiffness (N)	Color		
		*L **	*a **	*b **
Treatment (R)				
Control	2.44 ± SE b	66.31 ± SE b	2.21 ± SE a	40.39 ± SE a
0.5% Acid	3.02 ± SE a	75.76 ± SE a	0.25 ± SE b	35.71 ± SE b
1% A cid	2.62 ± SE b	73.58 ± SE a	0.31 ± SE b	38.39 ± SE ab
F Test Say	**ns**	**ns**	**ns**	**ns**
Storage period (Day)				
0	2.64 ± SE b	77.78 ± SE a	-0.64 ± SE a	42.69 ± SE a
4	3.02 ± SE a	70.19 ± SE b	1.46 ± SE b	39.07 ± SE b
8	2.94 ± SE a	71.41 ± SE b	1.71 ± SE b	35.97 ± SE bc
12	2.75 ± SE a	68.16 ± SE b	1.35 ± SE b	34.92 ± SE c
F-Test Say (RxH)	**ns**	**ns**	**ns**	**ns**

Each value is the average of three replications. Means with the same letter are not significantly different from the mean at the 5% level ($p < 0.05$) according to Duncan's Multiple Range Test (DMRT) L* Brightness, NS-Not significantly significant, **-Very significant

3.1. Stiffness

The firmness of fresh-cut pineapple in this study ranged from 2.44 to 3.02 N during storage at 5 °C. Although no statistically significant differences were observed among treatments (p > 0.05), treatment 2 (0.5% ascorbic acid) consistently showed a slightly higher firmness value, indicating better maintenance of tissue integrity during cold storage.

Quantitatively, these firmness values are comparable to those reported by Djioua et al. (2009) , who found firmness values of fresh-cut pineapple stored at 4 °C ranging from 2.3 to 3.1 N, with samples treated with ascorbic acid exhibiting slower softening compared to untreated controls. Similarly, Calderón (2010) reported firmness values between 2.5 and 3.4 N for fresh-cut pineapple under modified packaging conditions, highlighting that antioxidant treatment and low-temperature storage play an important role in preserving texture.

In the absence of antioxidant treatment, fresh-cut pineapple commonly exhibits a more pronounced decline in firmness during cold storage. Texture softening is closely associated with increased activity of cell wall–degrading enzymes such as polygalacturonase (PG) and pectin methylesterase (PME), which accelerate pectin solubilization and weaken cell wall structure. The degradation of structural polysaccharides reduces tissue integrity and results in progressive textural deterioration over storage time. Conversely, the relatively higher firmness observed in the present study indicates that the application of ascorbic acid at a moderate concentration (0.5%) may help limit oxidative stress and enzymatic breakdown, thereby slowing pectin degradation and maintaining structural stability in fresh-cut pineapple (Parafati et al., 2020) . The firmness values obtained in the present study fall within the upper range reported in their review for climacteric fresh-cut fruits treated with protective agents, supporting the role of ascorbic acid in stabilizing cell wall structure.

Overall, compared with previous studies, the firmness retention observed in this research demonstrates that 0.5% ascorbic acid treatment combined with storage at 5 °C is quantitatively effective in maintaining pineapple stiffness, with results comparable or slightly superior to those reported at lower storage temperatures (4 °C). This indicates that the selected storage temperature and antioxidant concentration offer a practical alternative for commercial fresh-cut pineapple preservation.

3.2. Color Attribute

The L* (lightness) values of fresh-cut pineapple in this study ranged from 66.31 to 75.76, indicating a bright yellow color characteristic of ripe pineapple flesh. Treatment 2 (0.5% ascorbic acid) exhibited the highest L* value (75.76), reflecting a brighter and more visually appealing appearance. Quantitatively, these values are consistent with the findings of Djioua et al. (2009) , who reported L* values between 68.0 and 76.5 for fresh-cut pineapple treated with ascorbic acid and stored at 4 °C. Similarly, Calderón (2010) observed L* values ranging from 70.2 to 78.1 under optimized packaging conditions, suggesting that antioxidant treatment and low-temperature storage effectively preserve pineapple brightness.

The a* values observed in the present study ranged from 0.25 to 2.21, indicating a predominantly yellow color with a slight reddish hue. These values are comparable to those reported by Oms-Oliu et al. (2010) , who found a* values between 0.5 and 2.5 in fresh-cut fruits treated with antioxidant solutions. The relatively low and stable a* values observed suggest minimal browning-related red pigmentation development. Meanwhile, the b* values range from 35.71 to 40.39, indicating a strong and stable yellow intensity during storage. These values fall within the range reported by Rojas-Graü et al. (2009) , who documented b* values of 34–42 in antioxidant-treated fresh-cut fruits stored under refrigerated conditions. In contrast, untreated samples in previous studies showed a decline in b* values to below 30, reflecting pigment degradation and loss of visual quality (Hong & Gross, 2001) .

The absence of significant color changes (p > 0.05) across treatments in the present study confirms that the combination of ascorbic acid treatment and storage at 5 °C effectively minimized enzymatic browning and pigment degradation. Quantitatively, the color stability observed is comparable to or slightly better than that reported at lower storage temperatures (4 °C), as documented by Djioua et al. (2009) , indicating that 5 °C remains an effective and more commercially realistic storage temperature. Overall, compared with previous studies, the present research demonstrates that 0.5% ascorbic acid treatment maintains color attributes within the upper range of reported values, highlighting its effectiveness in preserving visual quality and consumer acceptability of fresh-cut pineapple. Table 2 shows the effect of different ascorbic acid treatments on total soluble solids (SSC), sugar–acid ratio, ascorbic acid content, and titratable acidity (TTA) of pineapple stored at 5 °C. Data are presented as mean ± standard error (SE) at a 97% confidence level.

3.3. Dissolved Solids Content (SSC)

The SSC values of fresh-cut pineapple in this study ranged from 17.73 to 19.04 °Brix, with no significant differences among treatments (p > 0.05). These values are comparable to those reported by Djioua et al. (2009) , who observed SSC values between 18.0 and 19.5 °Brix in fresh-cut pineapple stored at 4 °C, indicating minimal sugar degradation during cold storage. Similarly, Calderón (2010) reported SSC values of approximately 17.5–20.0 °Brix under refrigerated storage conditions. The close agreement of SSC ranges confirms that storage at 5 °C is equally effective in maintaining soluble solids content by limiting respiratory sugar consumption, consistent with the findings of the research.

Table 2. Soluble solids content (SSC), sugar acid ratio, ascorbic acid content, titratable acid content (TTA) for pineapple stored at 5 °C.

Factor	SSC (^{0} Brix)	/ acid ratio (SAR)	Sour ascorbate (vitamin C) (mg/100g)	TTA (% Citric AC ID)
Treatment				
Trt 1	19.04 ± SE a	40.89 ± SE a	11.68 ± SE c	3.70 ± SE c
Trt 2	17.83 ± SE b	31.38 ± SE c	27.31 ± SE b	4.56 ± SE a
Trt 3	17.73 ± SE ab	32.56 ± SE b	28.53 ± SE a	4.29 ± SE b
F Test Say	**ns**	*	*	*
Storage (Day)				
0	16.57 ± SE d	31.60 ± SE c	34.18 ± SE a	4.13 ± SE b
4	20.56 ± SE a	39.97 ± SE a	18.05 ± SE c	4.10 ± SE bc
8	17.13 ± SE c	31.42 ± SE c	21.57 ± SE b	4.48 ± SE a
12	18.54 ± SE b	36.78 ± SE b	16.23 ± SE d	4.02 ± SE c
F-Test Say (DxT)	**ns**	*	*	*

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3.4. Sugar to Acid Ratio

The sugar–acid ratio is an important indicator of sweetness and overall flavor quality in fresh-cut pineapple. In this study, the sugar–acid ratio varied significantly among treatments ($p < 0.05$), ranging from 31.38 to 40.89, with the highest value observed in treatment 1 (40.89), followed by treatment 3 (32.56) and treatment 2 (31.38). The lower ratios in samples treated with higher concentrations of ascorbic acid indicate a relative increase in acidity rather than a reduction in sugar content.

Quantitatively, these results are consistent with previous studies. Djioua et al. (2009) reported sugar–acid ratios ranging from 30 to 42 in fresh-cut pineapple stored under refrigerated conditions, while Zhang et al. (2024) observed a decrease in sugar–acid ratio from approximately 38 to 32 in antioxidant-treated fresh-cut fruits due to increased titratable acidity. The similarity in value ranges confirms that antioxidant application, particularly ascorbic acid, influences flavor perception mainly by modifying acid balance rather than altering soluble sugar levels.

3.5. Ascorbic Acid Content

The ascorbic acid content of fresh-cut pineapple in this study differed significantly among treatments ($p < 0.05$), ranging from 11.68 to 28.53 mg/100 g. The highest ascorbic acid level was observed in treatment 3 (1% ascorbic acid; 28.53 mg/100 g), followed closely by treatment 2 (0.5% ascorbic acid; 27.31 mg/100 g), while the control showed the lowest value (11.68 mg/100 g). These results quantitatively demonstrate that immersion in ascorbic acid solutions effectively enhances or preserves vitamin C content in fresh-cut pineapple during refrigerated storage.

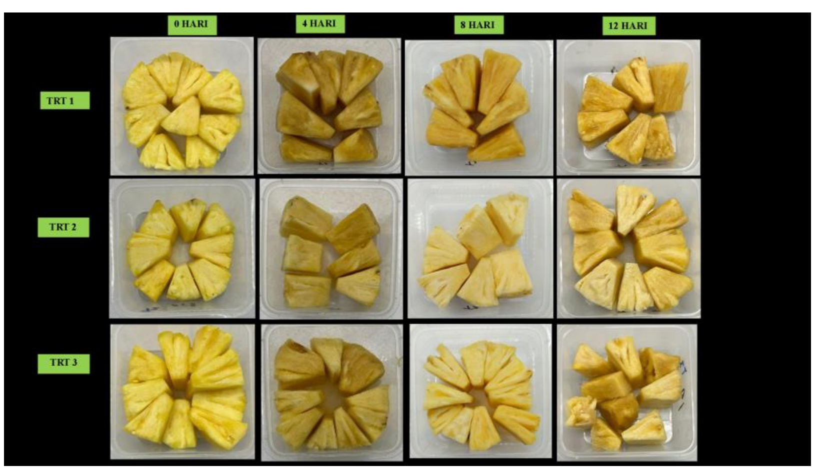

Figure 3. Appearance of fresh pineapple slices treated with various concentrations of ascorbic acid at a storage temperature of 5 °C

Comparable findings have been reported in previous studies. The application of antioxidant treatments has been shown to significantly preserve ascorbic acid levels in fresh-cut fruits during storage. Treated samples generally maintain substantially higher vitamin C concentrations compared to untreated controls, which tend to exhibit rapid degradation due to oxidative processes and tissue disruption. The protective effect is primarily attributed to the ability of antioxidant compounds to reduce enzymatic browning and limit oxidative reactions that accelerate ascorbic acid loss (Sogvar et al., 2016) . Similarly, Manolopoulou & Varzakas (2011) reported that ascorbic acid treatments maintained vitamin C levels at approximately 26–30 mg/100 g during cold storage, compared to rapid losses in control samples. The close agreement between these quantitative ranges confirms that ascorbic acid functions not only as a vitamin supplement but also as an effective protective agent against oxidative degradation, consistent with the results obtained in the present study.

3.6. Total Titration Acidity (TTA)

TTA values ranged from 3.7-4.56% citric acid, showing significant differences ($p < 0.05$) between treatments. Treatment 2 recorded the highest acidity (4.56%), followed by treatment 3 (4.29%) and Treatment 1 (3.7%). This increase in acidity is likely due to the direct contribution of added ascorbic acid as well as the stability of organic acids during cold storage. According to Calderón (2010) the combination of low temperature and antioxidant treatment can slow the enzymatic degradation of organic acids, thus maintaining the overall acidity level of cut fruit.

4. Conclusion

This study demonstrates that applying 0.5% ascorbic acid is the most effective treatment for maintaining the quality of fresh-cut pineapple during storage at 5 °C. This concentration provides an optimal balance of firmness, color stability, acidity, and vitamin C retention, while effectively delaying softening and minimizing physical deformation. Notably, it proved more effective than higher concentrations, highlighting that optimizing antioxidant dosage is more beneficial than simply increasing its concentration. Another key advantage of this research is its comprehensive evaluation of physicochemical and nutritional changes at 5 °C, a temperature that better represents commercial distribution and retail conditions compared to previous studies. Based on these findings, fresh-cut pineapple producers are recommended to apply a 0.5% (w/v) ascorbic acid dipping treatment for approximately one minute, followed by storage in airtight packaging at 5 °C. This method is safe, cost-effective, easy to implement at both small and large industrial scales, and effective in delivering fresher, visually appealing, and nutritionally superior products with extended shelf life while reducing postharvest losses.

References

Calderón, M. M. (2010). *Internal quality profile and influence of packaging conditions on fresh-cut pineapple* (Doctoral thesis). Universitat de Lleida.

Chen, D., Zhang, Y., Zhao, J., Liu, L., & Zhao, L. (2024). Research progress on physical preservation technology of fresh-cut fruits and vegetables. *Horticulturae, 10*, 1–19. https://doi.org/10.3390/horticulturae10101098

Djioua, T., Charles, F., Lopez-Lauri, F., Filgueiras, H., Coudret, A., Jr., M. F., Ducamp-Collin, M. N., & Sallanon, H. (2009). Improving the storage of minimally processed mangoes (*Mangifera indica* L.) by hot water treatments. *Postharvest Biology and Technology, 52*(2), 221–226. https://doi.org/10.1016/j.postharvbio.2008.10.006

Hong, J. H., & Gross, K. C. (2001). Maintaining quality of fresh-cut tomato slices through modified atmosphere packaging and low temperature storage. *Journal of Food Science, 66*(7), 960–965. https://doi.org/10.1111/j.1365-2621.2001.tb08219.x

Manolopoulou, E., & Varzakas, T. (2011). Effect of storage conditions on the sensory quality, colour and texture of fresh-cut minimally processed cabbage with the addition of ascorbic acid, citric acid and calcium chloride. *Food and Nutrition Sciences, 2*, 956–963. https://doi.org/10.4236/fns.2011.29130

Naibaho, A., Ketaren, B. R., & Ghazali, N. S. (2025). Pengaruh perlakuan pendinginan (pre-cooling) dan sanitasi pada kualitas tomat selama penyimpanan di suhu ruang. *Jurnal AGRIFOR, 24*(1), 111–118. https://doi.org/10.31293/agrifor.v24i1.8278

Oms-Oliu, G., Rojas-Graü, M. A., González, L. A., Varela, P., Soliva-Fortuny, R., Hernando, M. I. H., Munuera, I. P., Fiszman, S., & Martín-Belloso, O. (2010). Recent approaches using chemical treatments to preserve quality of fresh-cut fruit: A review. *Postharvest Biology and Technology, 57*(3), 139–148. https://doi.org/10.1016/j.postharvbio.2010.04.001

Palumbo, M., Attolico, G., Capozzi, V., Cozzolino, R., Corvino, A., Lucia, M., Chiara, V. D., Pace, B., Pelosi, S., Ricci, I., Romaniello, R., & Cefola, M. (2022). Emerging postharvest technologies to enhance the shelf-life of fruit and vegetables: An overview. *Foods, 11*(23), 3925. https://doi.org/10.3390/foods11233925

Parafati, L., Restuccia, C., Palmeri, R., Fallico, B., & Arena, E. (2020). Characterization of prickly pear peel flour as a bioactive and functional ingredient. *Foods, 9*(9), 1189. https://doi.org/10.3390/foods9091189

Puspitasari, A. M., & Seftiono, H. (2023). Pengaruh alginat sebagai edible coating terhadap kualitas buah potong klimakterik: Kajian pustaka. *Jurnal Teknik, 15*(2), 305–314. https://doi.org/10.24853/jurtek.15.2.305-314

Rojas-Graü, M. A., Soliva-Fortuny, R., & Martín-Belloso, O. (2009). The use of packaging techniques to maintain freshness in fresh-cut fruits and vegetables. *International Journal of Food Science and Technology, 44*, 875–889. https://doi.org/10.1111/j.1365-2621.2009.01911.x

Serrano, M., Martínez-Romero, D., Guillén, F., Castillo, S., & Valero, D. (2006). Maintenance of broccoli quality and functional properties during cold storage as affected by modified atmosphere packaging. *Postharvest Biology and Technology, 39*(1), 61–68. https://doi.org/10.1016/j.postharvbio.2005.08.004

Sogvar, O. B., Saba, M. K., & Emamifar, A. (2016). Aloe vera and ascorbic acid coatings maintain postharvest quality and reduce microbial load of strawberry fruit. *Postharvest Biology and Technology, 114*, 29–31. https://doi.org/10.1016/j.postharvbio.2015.11.019

Valenzuela, J. L. (2023). Advances in postharvest preservation and quality of fruits and vegetables. *Foods, 12*(9), 1830. https://doi.org/10.3390/foods12091830

Zhang, W., Xu, M., Feng, Y., Mao, Z., & Yan, Z. (2024). The effect of procrastination on physical exercise among college students: The chain effect of exercise commitment and action control. *International Journal of Mental Health Promotion*. https://doi.org/10.32604/ijmhp.2024.052730