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Effect of Papaya (*Carica papaya* L.) Fortification on the Physico-Chemical Properties, Sensory Attributes, and Nutritional Quality of Cantaloupe Jam (*Cucumis melo* L.)

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ABSTRACT

This study aimed to evaluate the effect of papaya fortification on the physicochemical and organoleptic characteristics of cantaloupe (*Cucumis melo* var.) jam at different formulation ratios. The research applied a Completely Randomized Design (CRD) with six treatments: 100% cantaloupe fruit (control), 500:500, 550:450, 600:400, 650:350, and 700:300 (cantaloupe:papaya, g). Jam was prepared through standard heating and gel formation using sugar as a sweetener. Parameters observed included vitamin C content, color attributes (L*, a*, b*), and sensory properties (color, aroma, taste, and texture). Data were analyzed using (ANOVA) followed by the LSD test at a 5% significance level. The results indicated that papaya addition significantly affected vitamin C content and all organoleptic parameters. The highest vitamin C value was found in the 500:500 formulation, suggesting optimal nutrient retention at balanced fruit proportions. Increasing papaya proportion enhanced redness (a*) and yellowness (b*) due to carotenoid contribution, although lightness (L*) decreased. Sensory evaluation showed that the 700:300 ratio achieved the highest scores for color (122.30), aroma (115.67), taste (123.33), and texture (118.33), significantly outperforming the control. Papaya fortification improves both nutritional and sensory quality of Cantaloupe jam, with the 700:300 ratio identified as the most preferred formulation.

INTRODUCTION

Tropical fruits are widely recognized for their high nutritional value, particularly as important sources of dietary fiber, essential minerals, vitamins, and diverse bioactive compounds. However, their inherently high moisture content accelerates postharvest physiological deterioration and microbial spoilage, resulting in substantial quantitative and qualitative losses along tropical supply chains. These losses reduce food availability, compromise nutritional security, and threaten the economic sustainability of smallholder farmers who rely heavily on seasonal horticultural commodities. Therefore, the development of value-added processed products such as fruit jam represents a strategic approach to extend shelf life, stabilize product quality, reduce postharvest losses, and enhance income continuity within tropical horticultural systems.

Cantaloupe (*Cucumis melo* L.), is a seasonal tropical fruit widely consumed for its refreshing taste, mild sweetness, and characteristic aroma. Despite its consumer appeal, cantaloupe possesses high moisture content and relatively low natural pectin levels, which contribute to its short postharvest life and limited structural stability in processed forms. These compositional characteristics may result in weak gel formation and suboptimal texture when cantaloupe is processed into jam without appropriate formulation adjustments. Consequently, technological modification through blending or fortification strategies becomes essential to improve both structural integrity and nutritional value.

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Structurally, jam is a semi-solid three-dimensional gel system formed by heating fruit pulp in the presence of sugar, acid, and pectin. Its stability and quality are strongly governed by key physicochemical parameters, including pH, titratable acidity (TA), total soluble solids (TSS), and moisture content. These parameters regulate gel formation kinetics, microbiological stability, water-binding capacity, viscosity development, and overall sensory perception. Interactions among sugars, organic acids, pectin, and bioactive compounds determine network formation, structural strength, and color retention. Therefore, variations in fruit composition significantly influence both technological performance and consumer acceptance of the final product (Pinandoyo & Masnar, 2020).

Papaya (*Carica papaya* L.) is characterized by bright orange flesh rich in carotenoids particularly β-carotene as well as phenolic compounds, vitamin C, and other phytochemicals with antioxidant potential. In addition to its nutritional richness, papaya contains appreciable amounts of natural pectin, which may contribute to improved gel strength and viscosity in fruit-based products. However, papaya is highly perishable due to rapid softening and enzymatic degradation after harvest, making processing an effective strategy to preserve its nutritional components and reduce postharvest losses (Dhushane & Mahendran, 2020).

Fruit fortification through blending strategies has gained increasing attention in functional food development. The incorporation of papaya into cantaloupe jam presents a complementary matrix approach: papaya may enhance pigment intensity, antioxidant capacity, and nutritional density, while simultaneously contributing to gel network reinforcement through natural pectin content. Previous studies on fruit-based fortification systems demonstrate that plant-derived additions can significantly increase total phenolic content, carotenoids, mineral levels, and antioxidant activity, depending on the proportion and compatibility of raw materials (Đorđević et al., 2020; Hussain et al., 2023). Nevertheless, bioactive enhancement must be balanced with the maintenance of physicochemical stability and acceptable sensory attributes (Owino & Ambuko, 2021).

The interaction between two fruit matrices within a fortified jam system may modulate gel network formation through sugar-acid-pectin synergy and bioactive compound interactions. While papaya fortification theoretically increases antioxidant concentration and color intensity, compositional differences between cantaloupe and papaya may also influence TSS, pH, viscosity, gel strength, and color stability. Empirical studies report that fruit fortification can significantly alter textural characteristics and physicochemical parameters, thereby requiring systematic formulation-specific evaluation (Nafri et al., 2021; Shahidan et al., 2022). Moreover, maintaining microbiological safety and physicochemical stability during storage is critical for commercial feasibility (Honesová et al., 2024).

From a nutritional standpoint, papaya incorporation may enhance total carotenoids, total phenolic compounds, vitamin C, and selected minerals in cantaloupe jam. However, excessive fortification may disrupt flavor balance, aroma profile, sweetness acidity equilibrium, and textural perception, potentially reducing overall consumer acceptance (Jebreen & Aznam, 2024; Bhanj & Das, 2021). This suggests that the response to papaya fortification may follow a curvilinear pattern, in which an optimal proportion maximizes nutritional enrichment without compromising gel stability and sensory quality.

Although interest in tropical fruit fortification is increasing, comprehensive studies integrating physicochemical, nutritional, and sensory evaluations of papaya-fortified cantaloupe jam remain limited. A systematic investigation is therefore required to clarify how interactions between these two tropical fruit matrices influence gel structure, technological stability, antioxidant enrichment, and consumer acceptance.

This study aims to evaluate the effect of papaya fortification on the physicochemical properties (pH, titratable acidity, total soluble solids, moisture content, color index, viscosity, and gel strength), sensory attributes (color, aroma, taste, texture, and overall acceptability), and nutritional quality (total carotenoids, total phenolics, vitamin C, and selected minerals) of cantaloupe jam. By identifying the optimal fortification level and elucidating the underlying fruit matrix interactions, this research is expected to provide a scientific foundation for the development of nutritionally enhanced tropical fruit jam suitable for commercial-scale production without compromising technological stability or consumer acceptance.

MATERIALS AND METHODS

This study was conducted at the Postharvest Technology Laboratory, Faculty of Agriculture, Universitas Muslim Indonesia, from June to July 2025. The research employed a quantitative experimental approach to evaluate the effect of papaya (*Carica papaya* L.) fortification on the physicochemical properties, sensory attributes, and nutritional quality of cantaloupe (*Cucumis melo* L.) jam. An experimental design was selected to allow controlled manipulation of treatment variables and objective measurement of product responses under homogeneous laboratory conditions.

1. Experimental Design

The experiment was arranged using a Completely Randomized Design (CRD). The independent variable was the proportion of papaya pulp incorporated into cantaloupe pulp, while the dependent variables included physicochemical parameters (pH, total soluble solids, moisture content, and color), nutritional quality indicators, and sensory attributes. Six treatment formulations were established: P0 (100% cantaloupe pulp as control), P1 (500 g cantaloupe + 500 g papaya), P2 (550 g cantaloupe + 450 g papaya), P3 (600 g cantaloupe + 400 g papaya), P4 (650 g cantaloupe + 350 g papaya), and P5 (700 g cantaloupe + 300 g papaya). Each treatment was replicated three times, resulting in 18 experimental units. Randomization was applied in assigning treatments to minimize systematic bias.

2. Sampling Criteria

The primary materials consisted of fresh cantaloupe and California papaya fruits at optimal ripeness, obtained from a traditional market in Makassar, Indonesia. The population in this study comprised all jam products formulated from combinations of cantaloupe and papaya pulp. The total sample size consisted of 18 jam units derived from six treatment formulations with three replications each.

Fruit selection followed predefined inclusion criteria, including optimal ripeness, uniform size, absence of mechanical damage, and no visible signs of microbial spoilage. Fruits that were overripe, bruised, or physically deteriorated were excluded. Raw materials were selected using purposive sampling to ensure homogeneity and reduce variability in initial physicochemical characteristics. For sensory evaluation, semi-trained panelists were recruited based on their willingness to participate, absence of allergies to fruit-based products, and ability to assess color, aroma, texture, taste, and overall acceptability.

3. Jam Preparation Procedure

Jam preparation began with washing, peeling, and deseeding the cantaloupe fruits, followed by cutting the flesh into small pieces and blending it into a homogeneous pulp. Papaya fruits were processed using the same procedure. The respective fruit pulps were weighed according to treatment formulations and thoroughly mixed. The mixture was cooked over medium heat with the addition of 250 g of granulated sugar for each treatment. Cooking was conducted for approximately 30 minutes with continuous stirring until the desired gel consistency was achieved. The endpoint of cooking was determined using a cold-water drop test; the jam was considered adequately cooked when it maintained its structure without dissolving or dispersing in water. After cooling at room temperature, the jam was transferred into sterilized glass jars, sealed tightly, labeled, and stored for subsequent physicochemical, nutritional, and sensory analyses.

4. Data Analysis

Quantitative data obtained from physicochemical and nutritional analyses were subjected to analysis of variance (ANOVA) at a 5% significance level. When significant differences were detected, post hoc tests were performed to determine differences among treatment means. Sensory evaluation data were analyzed using appropriate statistical methods to assess differences in preference levels among treatments

RESULTS AND DISCUSSION

1. Jam Yield (%)

The results of observations on the analyzed parameter for each treatment are presented in Figure 1.

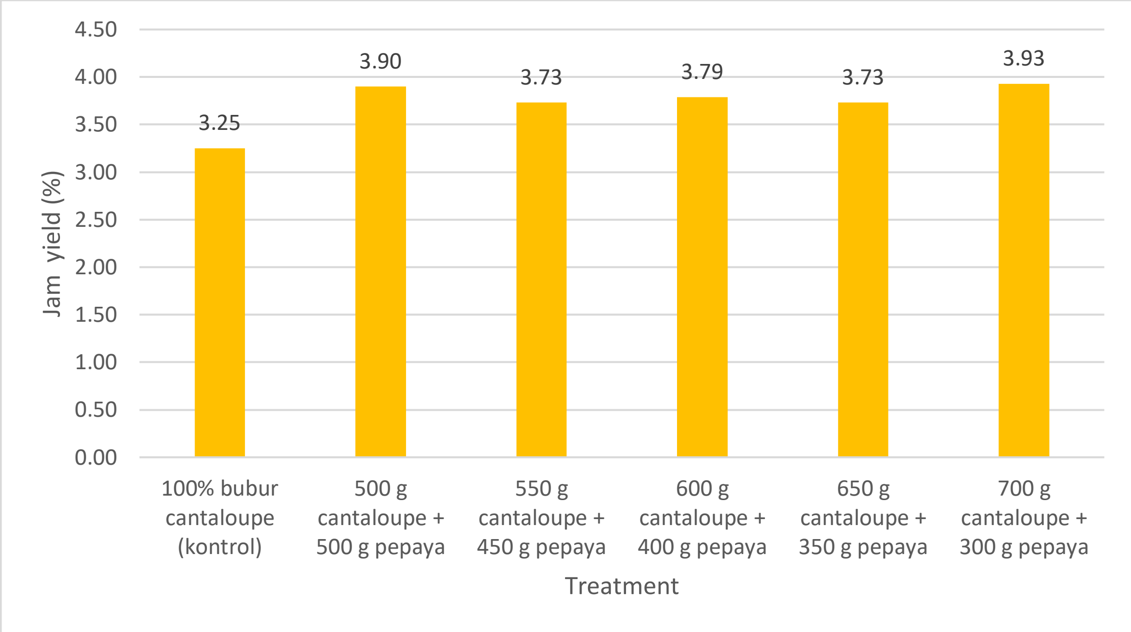

Figure 1. Average Jam yield (%) of Cantaloupe with the Addition of Papaya Fruit

Figure 1 presents the average jam yield (%) of cantaloupe formulated with varying proportions of papaya pulp. The control treatment (100% cantaloupe pulp) produced the lowest yield (25.79%) and served as the baseline for comparison. Papaya fortification generally increased yield, with the 500:500 and 550:450 formulations each reaching 28.90%, followed by 600:400 at 29.00%. The highest yield (29.50%) was obtained at the 700:300 ratio, whereas the 650:350 formulation showed a slight decline to 28.20%. Overall, papaya incorporation improved yield compared to the control; however, the response was not linear, indicating that yield enhancement depends on the specific cantaloupe:papaya ratio applied.

This variable pattern suggests complex physicochemical interactions during the cooking process, particularly involving pectin content, sugar concentration, moisture redistribution, and gel network formation. Papaya contains pectin and other polysaccharides that may interact with the cantaloupe matrix, influencing water-binding capacity and gel strength, which ultimately affect the final yield after cooking and gel setting. Previous studies have emphasized the functional role of papaya pulp and by-products in jam formulations and their influence on texture, gelling behavior, and overall product performance (Lekhuleni et al., 2021).

Although the cited literature does not specifically report cantaloupe-papaya jam yield data identical to the present findings, several studies consistently support the use of papaya as a functional ingredient capable of improving processing characteristics and adding value to fruit spread products. Papaya-based materials have been widely reported as promising fortifying agents for enhancing structural integrity, nutritional profile, and by-product utilization in jam and jelly production systems (Nguyen et al., 2024).

From a formulation perspective, the 700:300 (cantaloupe:papaya) ratio appears to represent the optimal range for achieving the highest yield among the tested blends. Nevertheless, yield optimization should be balanced with other quality attributes such as total soluble solids, acidity, color, texture, and sensory acceptance. The broader literature highlights that processing parameters, including heating time, temperature, and sugar concentration, strongly influence gelation behavior, nutrient retention, and product stability in papaya-fortified systems, thereby necessitating a multi-parameter optimization approach for industrial-scale applications (Veliu et al., 2025).

2. pH

The effect of papaya fortification on the pH value of cantaloupe jam is presented in Figure 2.

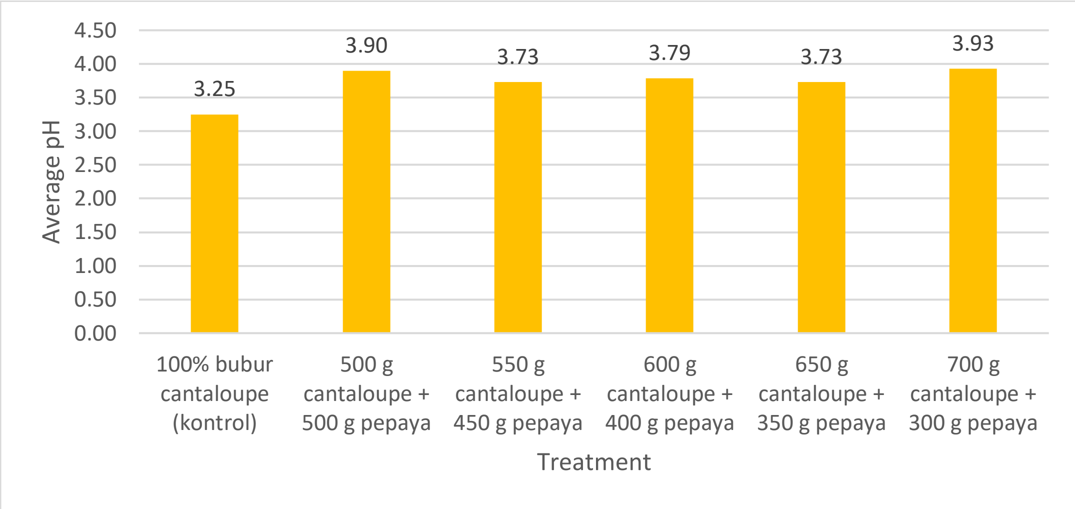

Figure 2. Average pH of cantaloupe jam with the addition of papaya fruit.

Figure 2 shows that the 100% cantaloupe control has the lowest pH (3.25), indicating the highest level of acidity in this system. In contrast, most cantaloupe-papaya blends exhibit higher pH values, reflecting reduced acidity following papaya fortification. The 500:500 (3.90), 550:450 (3.73), 600:400 (3.79), 650:350 (3.73), and 700:300 (3.93) formulations all display higher pH values than the control, with the 700:300 ratio showing the highest value. This increasing trend in pH with papaya addition is consistent with reports that mixed-fruit jams may exhibit different acidity profiles compared with single-fruit products due to compositional interactions during processing (Basary et al., 2022; Aziz, 2020).

The response observed is non-monotonic. Although papaya fortification generally increases pH, the rise does not occur linearly with increasing papaya proportion. For example, the 500:500 blend (3.90) shows a higher pH than the 550:450 and 650:350 formulations (both 3.73), while the 700:300 blend reaches the peak value (3.93). This pattern indicates complex interactions among organic acids, sugars, pectin, and water activity during cooking and gel formation. Such non-linear behavior is consistent with findings that interactions among polysaccharides, acids, and sugars in jam systems produce ratio-dependent buffering effects rather than simple additive responses (Veliu et al., 2025).

Papaya is recognized as a functional ingredient that influences gelation, texture, and acid balance in processed fruit products. Its pectin content and associated polysaccharides may contribute to buffering capacity or modify acid–solute interactions during heating, thereby affecting the final pH of the product. However, without supporting data such as titratable acidity, total organic acids, or pectin quantification, the precise mechanism underlying the observed pH changes cannot be definitively established. The available evidence supports the trend of increased pH with papaya addition, although the mechanism likely involves multifactorial interactions between composition and processing conditions (Leonarski et al., 2020).

From a formulation perspective, the tendency of papaya fortification to increase pH has implications for microbial stability, color stability, and sensory perception. Therefore, product developers should determine cantaloupe-papaya ratios that achieve the target pH range without compromising the desired texture and yield. To improve formulation precision, future studies are recommended to integrate pH analysis with measurements of titratable acidity, total soluble solids, and pectin content under controlled processing conditions, as heating regimes and sugar concentration may also influence acid balance and final pH values (Balogun & Ariahu, 2020).

3. Total Dissolved Solids

The results of the average total dissolved solids observation in Figure 3 show that the addition of papaya to winter melon jam does not have a significant effect on the total dissolved solids of the winter melon jam.

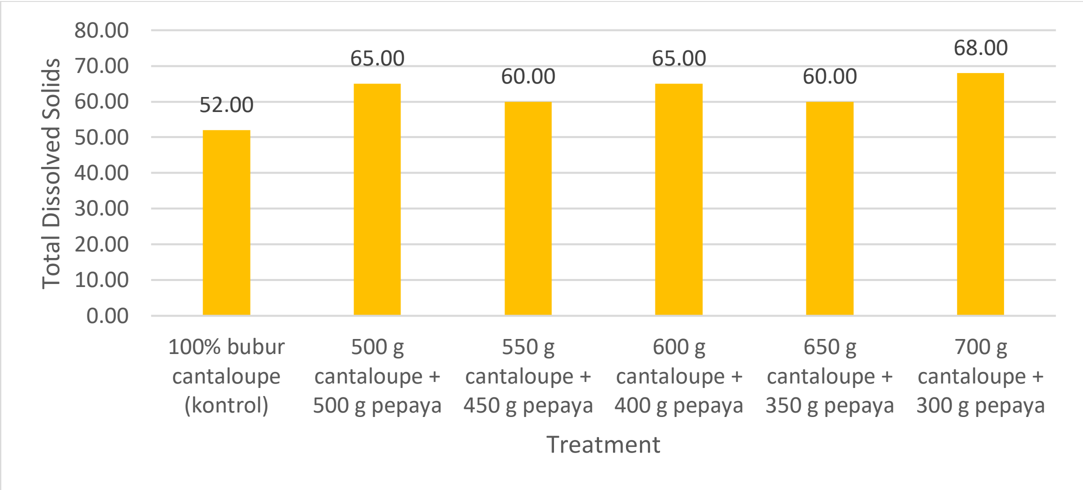

Figure 3. Average total dissolved solids (ºBrix) of melon preserves with the addition of papaya

Based on Figure 3, the control treatment (100% cantaloupe puree) showed the lowest Total Dissolved Solids (TDS) value at 52.00. In general, the addition of papaya in various proportions increased the TDS value compared to the control, indicating a rise in dissolved sugar content and other soluble components in the jam. This trend supports the interpretation that a blend of tropical fruits can modulate the profile of dissolved solids through the dynamics of sugars, organic acids, and soluble compounds during the initial processing stages, as reported in various studies on mixed fruit jams (Mada et al., 2022)

The treatment of 500 g cantaloupe + 500 g papaya and 600 g cantaloupe + 400 g papaya each resulted in a TDS of 65.00, indicating that certain proportions can significantly increase total dissolved solids. The treatments of 550 g + 450 g and 650 g + 350 g yielded a TDS of 60.00, suggesting that increasing or decreasing the amount of papaya does not always correlate directly with an increase in TDS. The highest value was obtained from the treatment of 700 g cantaloupe + 300 g papaya (68.00), indicating a nonlinear response to the mixture composition and the possibility of complex interactions among the dissolved components (Kong et al., 2021).

Papaya is suspected to significantly contribute to the increase in TDS due to its dissolved sugar content and other soluble compounds. However, the observed nonlinear pattern suggests an interaction between sugars, pectin, and gel-forming components, so the distribution of dissolved solids in the jam matrix is not solely determined by the amount of papaya added. Literature on mixed tropical fruit jams indicates that certain blend proportions can result in a peak TDS due to the synergy of chemical components, although in other combinations the increase does not occur gradually (Kumar et al., 2020; Valero et al., 2023).

An increase in TDS has the potential to enhance sweetness and affect the viscosity, texture, and gel stability of the jam. Therefore, using blend ratios such as 500:500 or 700:300 can be considered to achieve high TDS; however, this should still be correlated with sensory evaluation, pH, total sugar (TSS), total acid, as well as stability testing during storage. Further research, including more comprehensive chemical analysis and shelf-life testing, is needed to strengthen recommendations for the optimal proportions in developing mixed jam from cantaloupe and papaya.

4. Vitamin C Content

The results of the average vitamin C content observations indicate that the addition of papaya to cantaloupe jam has a highly significant effect on the vitamin C content of cantaloupe jam.

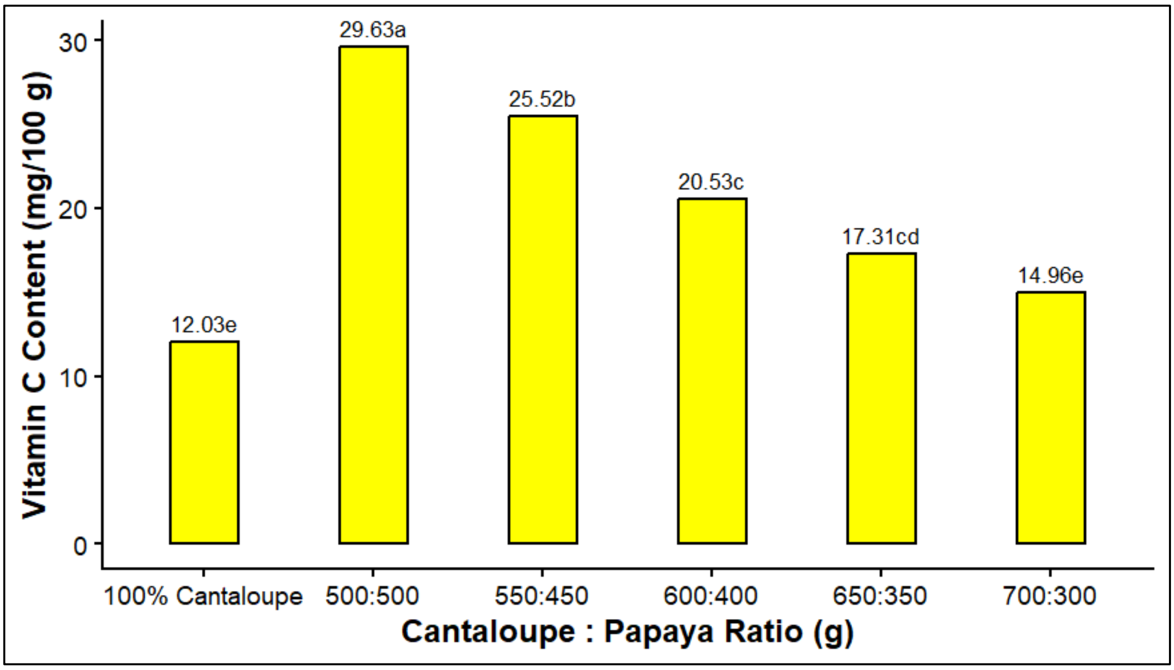

Figure 4. Average vitamin C content (mg/100g) of cantaloupe fruit jam with the addition of papaya, where values followed by different letters (a, b, c, d, and e) indicate a significant difference according to the 5% LSD test.

The fortification of papaya significantly increases the vitamin C content in melon jam, with the highest value recorded in the cantaloupe:papaya 500:500 formulation at 29.63 mg/100 g. This finding reinforces the role of papaya as a relatively high source of ascorbic acid compared to melon, so that increasing the proportion of papaya directly contributes to the rise in vitamin C levels in the mixed system. Literature shows that papaya-based jam products or mixtures containing papaya generally have higher vitamin C content compared to single-fruit products, especially when the raw materials are processed under conditions that still allow for ascorbic acid retention (Li et al., 2021). The low level of vitamin C in the control group (100% melon) further confirms that papaya is the dominant factor in increasing that value.

Interestingly, the peak vitamin C levels occurred at the balanced 50:50 ratio and were significantly different based on the LSD 5% test (notation a). This indicates that the increase in vitamin C is not solely proportional to the amount of papaya, but is also influenced by the interaction of the matrix during cooking and gel formation. Several studies have reported that intermediate mixing ratios can optimize nutrient stability because the balance between acid, sugar, and pectin content can minimize oxidative degradation during the thermal process (Minh, 2022). Thus, the highest value at the 500:500 ratio can be understood as the result of the combined contributions of the raw materials and system conditions that support vitamin C retention.

The decrease in vitamin C levels in the 550:450 to 700:300 formulations indicates that a reduction in the proportion of papaya is followed by a decrease in ascorbic acid content in the final product. Compositionally, this is logical because melon generally has a lower vitamin C content compared to papaya. Nevertheless, the response that is not entirely linear suggests that processing factors also play a role. Literature emphasizes that the stability of vitamin C is highly sensitive to heating temperature, cooking time, system pH, sugar concentration, as well as interactions with pectin, all of which can affect the availability and degradation of ascorbic acid during processing (Rashima et al., 2022).

5. Color Test

The results of color testing observations using an instrument on cantaloupe fruit jam can be seen in Table 6. The measurements produced L*, a*, and b* values, where (L*) represents the brightness parameter (achromatic color, 0: black to 100: white). The chromatic color mix of red and green is indicated by the (a*) value: a+ = 0-100 for red, a- = 0-(80) for green. The chromatic color mix of blue and yellow is indicated by the (b*) value: b+ = 0-70 for yellow, b- = 0-(-70) for blue (Engelen, 2017).

Table 1. The values of L*, a*, and b* from the color testing of each treatment sample using a colorimeter.

Treatment	L*	a*	b*
100% cantaloupe pulp (control)	58.54	3.61	32.81
500 g cantaloupe + 500 g papaya	51.45	21.26	26.43
550 g cantaloupe + 450 g papaya	49.48	23.40	30.96
600 g cantaloupe + 400 g papaya	53.20	16.67	31.25
650 g cantaloupe + 350 g papaya	51.41	22.42	37.27
700 g cantaloupe + 300 g papaya	50.39	19.68	29.39

Note: L* (light-dark), a* (red-green), and b* (yellow-blue).

Table 1 illustrates that the integration of papaya into cantaloupe fruit jam markedly affects the L*, a*, and b* color parameters across all treatments. The control group, consisting of 100% Cantaloupe , exhibited the highest L* value (58.54), which demonstrated a decreasing trend as the proportion of papaya increased, reaching its minimum at the 550:450 ratio (49.48). This decline in brightness indicates that papaya fortification results in a more intense or less bright color. This observation is consistent with existing literature, which suggests that an increase in pigment concentration in heated formulations generally leads to a reduction in the L* value due to enhanced color saturation (Ardiyan et al., 2021).

The a* value showed a consistent increase in all treatments containing papaya compared to the control, with the highest value recorded at the 550:450 ratio (23.40), followed by 650:350 (22.42) and 500:500 (21.26), while the control had the lowest value (3.61). This rise indicates a more intense redness due to the carotenoid pigments in papaya, which naturally give processed products a red–yellow or orange hue. Studies on papaya jam and fruit blends support that carotenoid content and interactions during heating can boost the a* value, signaling enhanced red tones in the CIELAB system (Simbolon & Baniah, 2023).

The b* parameter exhibited more variable fluctuations across different formulations, with the highest measurement recorded at a 650:350 ratio (37.27) and the lowest at 500:500 (26.43). Despite these differences, all samples maintained positive values, indicating a predominance of yellow coloration. This variability likely results from intricate interactions among papaya carotenoid pigments, pH, pectin, and heat treatment during the jam-making process. According to literature, the b* response in heated fruit products does not always follow a linear pattern, as the stability of yellow-orange pigments can be influenced by mild oxidation and changes in the matrix during heating (Sianipar et al., 2022).

The observed pattern of decreasing L*, increasing a*, and fluctuating b* values indicates that the proportion of winter melon to papaya significantly influences the color properties of jam, due to the presence of carotenoid pigments and the effects of thermal processing. The differences among treatments, as shown by letter notations in the 5% LSD test, align with standard statistical analysis methods used in fruit jam formulation research. In these studies, color differences between mixtures are often statistically significant, although some closely related groups may not exhibit a markedly different response (Jamaluddin et al., 2022). Therefore, the observed color changes can be both theoretically and empirically attributed to the ingredient composition and the heating dynamics during processing.

6. Organoleptic Test

Table 2 delineates the outcomes of the organoleptic evaluation of cantaloupe fruit jam, incorporating papaya at varying formulation ratios. The parameters assessed include color, aroma, taste, and texture. The evaluation employed a hedonic test, and values followed by distinct letters denote significant differences as determined by the 5% LSD test.

Table 2. Average Values of Organoleptic Tests (Color, Aroma, Taste, and Texture) of Cantaloupe fruit Jam with the Addition of Papaya at Various Formulation Ratios

Treatment	Color	Aroma	Taste	Texture
100% cantaloupe pulp (control)	46.00 f	112.33 bc	109.33 e	110.67 c
500 g cantaloupe + 500 g papaya	97.33 e	112.67 bc	119.67 b	110.67 c
550 g cantaloupe + 450 g papaya	104.30 d	113.33 b	115.33 d	110.00 c
600 g cantaloupe + 400 g papaya	107.70 c	111.33 c	117.33 c	111.33 b
650 g cantaloupe + 350 g papaya	111.30 b	113.33 b	116.33 cd	111.67 b
700 g cantaloupe + 300 g papaya	122.30 a	115.67 a	123.33 a	118.33 a

Note: numbers followed by different letters (a, b, c, d and e) indicate a significant difference according to the 5% LSD test.

Based on Table 6, the addition of papaya has a significant effect on all organoleptic parameters, namely color, aroma, taste, and texture. In general, increasing the proportion of papaya at certain ratios can simultaneously enhance sensory appeal, with the 700:300 winter melon:paya formulation showing the highest scores for color (122.30), aroma (115.67), taste (123.33), and texture (118.33). These values are consistently higher compared to the 100% winter melon control, which had the lowest scores across all parameters. These findings align with literature reporting that papaya fortification in mixed fruit jam products can improve sensory attributes through enrichment of color pigments as well as the synergistic aroma and taste between fruits (Pandesolang et al., 2022), noting that sensory responses in mixed systems are often non-linear.

In the context of color parameters, an increased proportion of papaya is associated with an enhancement of red-yellow/orange characteristics, as evidenced by elevated a* and b* values, although the L* value tends to decrease, resulting in a less bright color compared to the control. This reduction in L* does not necessarily imply a decline in visual quality; rather, it can be interpreted as an increase in pigment saturation due to the contribution of papaya carotenoids and the effect of heating during the jam-making process. The literature indicates that papaya carotenoids are relatively stable in sugar gel systems and can enhance color intensity in thermally processed products (Wiyono et al., 2023). The combination of increased a* and b* at a 700:300 ratio supports the panelists' perception of a more attractive color, while also indicating the presence of an optimal blend ratio that maximizes visual characteristics without relying solely on one type of fruit.

Regarding aroma and taste, the 700:300 formulation achieved the highest score and demonstrated a significant difference from most other treatments. This suggests that the combination of the characteristic volatiles of winter melon and papaya at this ratio yields a more balanced aromatic complexity. Previous research has indicated that blending papaya with other fruits can enhance the intensity and complexity of aroma due to the interaction of volatile compounds, which is affected by the proportion of ingredients and heat treatment (Aziz, 2020). A similar trend was observed in the taste parameter, where the balance of sugar–acid and the contribution of papaya's flavor components resulted in a more harmonious profile compared to the single control, without exhibiting a fully linear tendency of improvement with each increase in papaya proportion.

CONCLUSIONS

Papaya fortification significantly improved the sensory quality of cantaloupe fruit jam. The 700:300 (cantaloupe:papaya) ratio produced the highest scores for color, aroma, taste, and texture, indicating an optimal balance of pigment intensity, flavor complexity, and gel consistency. These findings confirm that appropriate fruit proportion enhances overall product acceptability. Future studies should evaluate storage stability and nutrient retention of the optimal formulation. Producers may apply the 700:300 ratio to obtain jam with improved sensory quality and consumer appeal.

REFERENCES

Ardiyan, E., Tari, A., & Asmoro, N. (2021). Karakteristi Sifat Fisik dan Organoleptik Fruit Leather Dengan Variasi Perbandingan Pepaya dan Daun Kelor. Pro Food, 7(1), 766-772. https://doi.org/10.29303/profood.v7i1.160

Aziz, Y. (2020). Preparation of value-added guava jam with addition of papaya. Pure and Applied Biology, 9(1). https://doi.org/10.19045/bspab.2020.90061

Balogun, A. and Ariahu, C. (2020). Quality Evaluation of Fresh Papaya Fruits Stored in Evaporative Coolers. Asian Food Science Journal, 6-16. https://doi.org/10.9734/afsj/2020/v15i230147

Basary, M., Premakumar, K., & Afreen, S. (2022). Development and Storage Study of Mixed Fruit Jams from Papaya and Pineapple Incorporated with Aloe vera. Asian Journal of Dairy and Food Research, (Of). https://doi.org/10.18805/ajdfr.drf-255

Dhushane, S. and Mahendran, T. (2020). Extraction of Pectin from Lemon (*Citrus limon* L.) fruit peels and its utilization in the Production of Watermelon (*Citrullus lanatus*) Jam. Journal of the University of Ruhuna, 8(1), 49-59. https://doi.org/10.4038/jur.v8i1.7964

Đorđević, Đ., Jančíková, S., Capikova, J., Tremlová, B., & Kushkevych, I. (2020). Chemical and sensory properties of fruit jams affected by bamboo fiber fortification. Biointerface Research in Applied Chemistry, 10(2), 5247-5251. https://doi.org/10.33263/briac102.247251

Honesová, S., Samková, E., Dadáková, E., Hasoňová, L., Jarošová, M., Reindl, K., & Bárta, J. (2024). Effect of Skimmed Milk Powder and Fruit Jams Addition on the Physicochemical Characteristics of Yogurt. Fermentation, 10(9), 462. https://doi.org/10.3390/fermentation10090462

Hussain, A., Akram, S., Siddique, T., Yaqub, S., Fatima, H., Arif, M., & Shehzad, A. (2023). Exploration of Two Cucurbitaceae Fruit (Muskmelon and Watermelon) Seeds for Presence of Phytochemicals, and Antioxidant and Antimicrobial Activities. Turkish Journal of Agriculture - Food Science and Technology, 11(s1), 2493-2498. https://doi.org/10.24925/turjaf.v11is1.2493-2498.6366

Jamaluddin, R., Mailoa, M., & Picauly, P. (2022). The Effect of The Addition of Papaya Puree on The Chemical and Organoleptic Properties of Pineapple Jam. Jurnal Agrosilvopasture-Tech, 1(2), 44-48. https://doi.org/10.30598/j.agrosilvopasture-tech.2022.1.2.44

Jebreen, A. and Aznam, N. (2024). Enriched of Orange Jam (Marmalade) with vitamin C. Journal of Agri-Food Science and Technology, 5(2), 94-101. https://doi.org/10.12928/jafost.v5i2.11455

Kong, Y. R., Jong, Y. X., Balakrishnan, M., Bok, Z. K., Weng, J. K. K., Tay, K. C., Goh, B. H., Ong, Y. S., Chan, K. G., Lee, L. H., & Khaw, K. Y. (2021). Beneficial Role of Carica papaya Extracts and Phytochemicals on Oxidative Stress and Related Diseases: A Mini Review. Biology, 10(4), 287. https://doi.org/10.3390/biology10040287

Kumar, S., Gehlot, R., Sindhu, R., & Malik, T. (2020). Changes in chemical constituents and overall acceptability of guava-papaya jam during storage. Journal of Pharmacognosy and Phytochemistry, 9(3), 1278-1281. https://doi.org/10.22271/phyto.2020.v9.i3u.11484

Lekhuleni, I., Kgatla, T., Mashau, M., & Jideani, A. (2021). Physicochemical properties of South African prickly pear fruit and peel: Extraction and characterisation of pectin from the peel. Open Agriculture, 6(1), 178-191. https://doi.org/10.1515/opag-2021-0216

Leonarski, E., Reis, N., Bertan, L., & Pinto, V. (2020). Optimization and sensorial evaluation of guabiroba jam with prebiotic. Pesquisa Agropecuária Brasileira, 55. https://doi.org/10.1590/s1678-3921.pab2020.v55.01841

Li, L., Yang, R., & Zhao, W. (2021). The Effect of Pulsed Electric Fields (PEF) Combined with Temperature and Natural Preservatives on the Quality and Microbiological Shelf-Life of Cantaloupe Juice. Foods, 10(11), 2606. https://doi.org/10.3390/foods10112606

Mada, T., Duraisamy, R., & Guesh, F. (2022). Optimization and characterization of pectin extracted from banana and papaya mixed peels using response surface methodology. Food Science & Nutrition, 10(4), 1222–1238. https://doi.org/10.1002/fsn3.2754

Minh, N. (2022). Quality attributes of cantaloupe (*Cucumis melo* L.) fruit under pre-harvest and post-harvest treatment with methyl jasmonate and salicylic acid. Plant Science Today, 9(1), 52-61. https://doi.org/10.14719/pst.1456

Nafri, P., Singh, A., Sharma, A., & Sharma, I. (2021). Effect of storage condition on physiochemical and sensory properties of papaya jam. Journal of Pharmacognosy and Phytochemistry, 10(2), 1296-1301. https://doi.org/10.22271/phyto.2021.v10.i2q.13990

Nguyen, T., Le, Q., Tran, M., Ta, K., & Nguyen, K. (2024). Antioxidant, Anti-Tyrosinase, and Wound-Healing Capacities of Soy Protein Hydrolysates Obtained by Hydrolysis with Papaya and Cantaloupe Juices Showing Proteolytic Activity. Polish Journal of Food and Nutrition Sciences, 5-15. https://doi.org/10.31883/pjfns/176894

Owino, W. and Ambuko, J. (2021). Mango Fruit Processing: Options for Small-Scale Processors in Developing Countries. Agriculture, 11(11), 1105. https://doi.org/10.3390/agriculture11111105

Pandesolang, N., Lalujan, L., & Oessoe, Y. (2022). Pengaruh Suhu dan Lama Pengeringan terhadap Karakteristik Kimia dan Sensoris Permen Jelly Pepaya (*Carica Papaya* L.). Jurnal Teknologi Pertanian (Agricultural Technology Journal, 13(2), 105-111. https://doi.org/10.35791/jteta.v13i2.50351

Pinandoyo, D. and Masnar, A. (2020). Changes in chemical constituents and overall acceptability of papaya jam fortified with soya protein during storage. E-Journal Menara Perkebunan, 88(1). https://doi.org/10.22302/iribb.jur.mp.v88i1.361

Rashima, S., R., Ong, W. L., Aina Nadiah, Z., & Maizura, M. (2022). Effects of acidified blanching water and pectinase enzyme pretreatments on physicochemical properties and antioxidant capacity of *Carica papaya* juice. *Journal of Food Science*, *87*(4), 1684–1695. https://doi.org/10.1111/1750-3841.16097

Shahidan, N., Ong, Y., Harith, S., Shahril, M., & Hapidin, H. (2022). Proximate Composition and Determination of Epigallocatechin Gallate Content in Melon Manis Terengganu. Halalsphere, 2(2), 17-24. https://doi.org/10.31436/hs.v2i2.34

Sianipar, Y., Sumual, M., & Assa, J. (2022). Penambahan Sari Jeruk Kalamansi (*Citrus Microcarpa*, B.) Dalam Pembuatan Selai Pepaya. Jurnal Teknologi Pertanian (Agricultural Technology Journal, 12(1), 1. https://doi.org/10.35791/jteta.v12i1.38854

Simbolon, Z. and Baniah, B. (2023). Perbandingan Metode City Block Dan Canberra Distance Dalam Identifikasi Kematangan Buah Pepaya Madu (*Callina Papaya*) Berdasarkan Warna RGB. jaise, 3(1), 14. https://doi.org/10.30811/jaise.v3i1.4135

Valero, A., Alonso-Calleja, C., Escámez, P., Franco, C., Sillué, S., & Sánchez, G. (2023). Report of the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) on the conservation conditions of halved fruits in retail establishments. EFS4, 1(1). https://doi.org/10.2903/sp.efsa.2023.fr-0002

Veliu, A., Abdullahi, X., Sulejmani, E., Çelik, Ö., Ölçer, M., & Öztürk, B. (2025). Effect of Pectin on the Quality Attributes and Phenolic Composition of Blackberry Jam from Wild and Cultivated Fruits at Different Altitudes. Foods, 14(19), 3420. https://doi.org/10.3390/foods14193420

Wiyono, A., Rani, I., Choiron, M., Setiawan, A., & Massahid, A. (2023). Kinetika Perubahan Mutu Sediaan Sabun Padat Transparan Dari Ekstrak Daun Pepaya (*Carica Papaya* L.). Jurnal Teknik Industri, 13(1), 35-44. https://doi.org/10.25105/jti.v13i1.17512