

# Physicochemical and Sensory Properties of Red Dragon Fruit Jam Incorporated with Honey

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## Abstract

This study focuses on the development and evaluation of red dragon fruit jam sweetened with honey, aiming to analyse its physicochemical properties and sensory acceptance. The research addresses the lack of tropical fruit jams in the Malaysian market by formulating a jam using ripe red dragon fruit and Tualang honey, a natural sweetener because of it has complicated sugar mixture primarily made up of oligosaccharides, fructose, glucose, and sucrose. These sugars affect the texture, crystallization, and overall quality of jam while also contributing to its sweetness. The primary objective is to assess the jam's quality through various physicochemical analysis, including total soluble solids (TSS), moisture content, pH, colour, and viscosity, alongside sensory evaluations with 50 untrained panellists using a 9-point hedonic scale. There are four formulations which are Control (Sugar Only), F1(Honey only), F2 (Honey+ sugar), and F3 (Honey + Sugar + Water) produced. Results indicated significant differences in pH across formulations, with values ranging from 3.357 (control) to 3.677 (honey + sugar + water), while TSS values were highest in the control formulation 55.73% compared to lower levels in honey-containing variants. Notably, the F2 formulation, which combines honey with a reduced amount of sugar, emerged as the most favourable in terms of both physicochemical properties and sensory acceptance. Moisture content also varied significantly; the control had 40.51% moisture against 56.94% for the formulation with added water. The incorporation of honey enhanced sensory attributes such as flavour complexity and texture but posed challenges for microbial stability due to higher moisture levels. Overall, this study successfully developed a red dragon fruit jam that meets consumer preferences for taste and quality, highlighting the potential of using tropical fruits in jam production and positioning honey as a viable alternative to traditional sweeteners. Further research is recommended to explore preservation techniques that enhance shelf life while maintaining product quality.

## 1. Introduction

Fruit jams are preserved mixtures of fruits and sugars, typically canned or sealed for long-term storage. The process of making jam involves breaking down the fruit tissue and heating it with added water and sugar to activate pectin before sealing it in containers [1] In Malaysia, the jam market is dominated by conventional fruit varieties such as grape, apricot, blueberry, and strawberry jams [1]. Despite the growing popularity of tropical

fruits, red dragon fruit jam incorporating honey has not yet been introduced in the Malaysian market. This study aims to formulate red dragon fruit jam with honey as a natural sweetener and evaluate its physicochemical and sensory properties. The objectives to develop and evaluate the quality and acceptance of dragon fruit jam with honey by analysing its physicochemical properties and sensory attributes.

Additionally, the fastest-growing jam flavours globally are those featuring exotic fruits like pomegranate and dragon fruit, which are experiencing a compound annual growth rate (CAGR) of 8–10% due to their visual appeal, vibrant colour, and health benefits by Spherical Insights in 2023 [2]. Formulating a jam that combines red dragon fruit and honey requires addressing key parameters such as viscosity, texture, flavour, and gel formation. Honey's higher water content compared to sugar can affect the jam's viscosity and spreadability, requiring adjustments in sweetener ratios and water content. Furthermore, dragon fruit's natural high moisture content and susceptibility to microbial growth contribute to a shorter shelf life [3]. Strategies such as concentrating honey through gentle heating could mitigate these challenges to overcome the problem [4].

Honey's natural properties may hinder proper gel formation, requiring innovative techniques or alternative ingredients to achieve the desired firmness and consistency [5]. Additionally, the effects of honey on flavour and sensory qualities, such as taste, aroma, and overall acceptability, need further exploration. From a physicochemical perspective, parameters such as total soluble solids (TSS), moisture content, pH, colour, and texture play vital roles in determining the quality of the jam. These factors must be optimized to ensure the product aligns with consumer preferences. By investigating the optimal ratios of honey, fruit, and pectin, along with preservation strategies to enhance shelf life by making jam, this research aims to create a red dragon fruit jam that meets consumer expectations. Addressing these challenges will provide insights into the diversification of the Malaysian jam which are red dragon fruit jam and the potential of honey as a natural sweetener in fruit-based products and reducing table sugar like sucrose in this study.

## 2. Methodology

### 2.1 Materials

The materials and ingredients include Red Dragon Fruit sourced from L&L and Top Opal markets in Pagoh Jaya 2, authentic Tualang honey purchased from the 'MaduMedina' shop on Shopee, food-grade citric acid, food-grade pectin as a thickening agent, food-grade sodium benzoate as preservatives, and traditional table sugar.

### 2.2 Preparation of Red Dragon Fruit Jam

The preparation of the jam began with ripe red dragon fruit being washed, peeled, and pulped. The pulp-to-sugar ratio was calculated using a 2:1 ratio (2 parts fruit to 1 part sugar by weight) for the control formulation [6]. A combination planning technique was employed to develop the jam formulations, allowing modifications in the amount of pulp based on Table 1.

The differences among the four formulations were as follows: the control formulation used honey as the sole sweetener, while F1 served as the base for the red dragon fruit incorporated honey formulation, using pure honey with no added sugar as the sweetener which F2 combined honey with a reduced amount of table sugar, partially substituting sucrose with honey, and F3 followed the same formulation as F2 but included an additional 50 mL of water to observe its effects in terms of physicochemical properties and overall acceptances among panellists.

For jam production, the ingredients were placed into a stainless-steel container and cooked at 103–105°C for 10 minutes or until a consistent gel-like texture was achieved. Citric acid was added to adjust the pH to 3.5, along with pectin and sodium benzoate for stabilization. Once the jam reached a temperature above 85°C, it was poured into pre-sterilized glass jars, sealed with metal lids, and inverted for 5 minutes to ensure proper sealing. After cooling, the jars were stored at room temperature [6].

### 2.3 Formulation of Red Dragon Fruit Jam

Based on Table 1, the formulation of red dragon fruit jam involves four different variants which are Control, F1, F2, and F3. Each formulation uses 300 g of dragon fruit and 3 g of pectin as the base ingredients. Additionally, 1 g of sodium benzoate and 2 g of citric acid are included in every recipe for preservation and acidulants. The Control formulation uses 150 g of sugar as a sweetener, with no honey or water added. In contrast, the F1 formulation eliminates sugar entirely, replacing it with 150 g of honey, maintaining the sweetness naturally. Similarly, the F2 and F3 formulations each use 40 g of sugar and 110 g of honey as sweetening agents, creating a balance of flavours. However, what sets F3 apart is the inclusion of 50 mL of water, making it distinct from the other formulations. The formulation was followed and referred [7][8].

**Table 1** Formulation of Red Dragon Fruit Jam

Ingredients	Control	F1	F2	F3
Dragon Fruit (g)	300	300	300	300
Sugar (g)	150	0	40	40
Pectin (g)	3	3	3	3
Honey (g)	0	150	110	110
Sodium benzoate (g)	1	1	1	1
Citric Acid (g)	2	2	2	2
Water (mL)	0	0	0	50

## 2.4 Physicochemical properties of Dragon Fruit Jam incorporated Honey

### 2.4.1 Acidity and pH

A digital glass electrode pH metre has been used to measure the samples' pH at room temperature. Prior to measuring the pH of the sample, the instrument has calibrated using buffer solutions with pH values of 4.0 and 7.0 [9]. Specifically, 5 g of each batch of jam was mixed with 50 mL of distilled water to make a 10% solution. The resulting filtrate have been then tested for pH using a digital pH meter [10].

### 2.4.2 Total Soluble Solid (TSS)

A refractometer was used to measure the total soluble solid content in the red dragon fruit jams. The total soluble solids of the samples were also determined using a hand refractometer with a range of 0 to 80 °Brix [9]. 1 ml of jam was applied to the refractometer's prism following calibration and the cleaning of the prism with a soft tissue. Measurements were shown on the brix meter and the values were obtained in triplicate [11].

### 2.4.3 Moisture Content

The moisture contents of fruit jam were evaluated using a rapid moisture analyzer (MX-50 A&D, Japan). Then, the moisture content of the samples was measured in percentages in triplicate at a temperature of 160°C for jam and wait until the moisture analyzer stop before collected the data [12].

### 2.4.4 Colour

The colour of the jam samples was analysed using a Konica Minolta R-300 chromameter or the CIELAB system at ICA Lab UTM which colorimeter illuminator: D65, observation angle: 10°. Measurements were taken at three different spots on each sample to calculate the lightness ( $L^*$ ) of the jams [10]. The values of lightness ( $L^*$ ), redness or greenness ( $a^*$ ), and blueness or yellowness ( $b^*$ ) were measured. These values were then analysed [13]. The measurement was performed in triplicate.

### 2.4.5 Viscosity

Viscosity measurements were carried out using the Viscometer. The tests were performed in controlled stress mode to assess the viscosity of different jam compositions. About 250 grams of jam was placed in the fixed rheometer cup. Viscosity readings were taken at a temperature range of 21°C ( $\pm 1$ ) [14] and it were performed by using spindle size 05 at unit Centipoise (cP). The measurement was performed in triplicate.

### 2.4.6 Sensory Evaluation

Fifty individuals with no prior training in sensory evaluation participated as panellists to evaluate various sensory attributes of the jams, encompassing aspects such as colour, appearance, texture, aroma, taste, and overall acceptance. Employing the 9-point Hedonic scale, these panellists rated the jams based on their perceptions. The Hedonic scale ranged from 1 to 9, where 1 denoted "Dislike Extremely" and 9 signified "Like Extremely," offering a nuanced evaluation framework [15]. Furthermore, the degree of similarity among the jams was gauged through a structured questionnaire employing the Hedonic scale. This questionnaire was designed to capture respondents' perceptions of the jams' likeness, considering the range of attributes evaluated and have been shared through Google Form. Subsequently, statistical analysis, specifically ANOVA, was utilized to interpret and assess the data gathered through the Hedonic scale questionnaire, providing insights into the perceived similarities among the jams as assessed by the panellists [16].

### 2.4.7 Statistical Analysis

The results were expressed as mean  $\pm$  Standard deviation. Then, One-way ANOVA is performed to determine the mean, standard deviation, and significant differences among groups. Means were calculated for various subsets of the data by grouping the data based on specific criteria. The data was segregated into distinct groups, and the mean was calculated for each subset to analyse differences and trends effectively. The means for each subset were calculated and segregated to allow for a detailed comparison between the groups. This involves navigating to Analyze > Compare Means > One-Way ANOVA in SPSS, selecting the dependent variable for analysis, and grouping by the independent variable. To determine significant differences, post-hoc tests such as Tukey's HSD can be used if the ANOVA indicates significance ( $p < 0.05$ ) at a 95% confidence level. These tests highlight which specific groups differ significantly [17].

## 3. Results and Discussion

### 3.1 Acidity and pH

Table 2 shows the pH values of red dragon fruit jam formulations ranged from 3.357 (Control) to 3.677 (F3), indicating significant differences across the samples due to the incorporation of honey and variations in the formulations. The control which has sugar had the lowest pH, reflecting the natural acidity contributed solely by the fruit and sugar. This is because high concentration of sugar not only enhances sweetness but also helps preserve the jam by binding water molecules and reducing water activity, which is critical for preventing microbial growth [18].

In contrast, formulations containing honey (F1, F2, F3) demonstrated higher pH values than control. The combination of honey and sugar in the jam formulation F2 produces a pH nearly to the sugar-only formulation, Control compared to other two formulation (3.620 vs. 3.357), making it a viable option for maintaining texture. This demonstrates that the honey and sugar combination is as effective as sugar only in terms of pH stability, as it remains within the optimal range for preservation and texture formation.

Additionally, honey offers added benefits such as a more complex flavour profile and nutritional advantages like lower glycaemic index, higher fructose content, and stronger sweetening ability [19], without compromising the fundamental physicochemical properties of the jam, making it a practical and enhanced alternative to using sugar only as sole sweetener. F1 also has the nearest value of pH with F2 and F3 which is 3.620 because of red dragon fruit already classified as a low-acid fruit with a pH range of 4.5 to 5.0 due to acidity is primarily due to malic acid [3] and when honey is added to red dragon fruit jam, the already higher pH of the fruit can be further elevated little, as Tualang honey typically has a pH ranging from 3.55 to 4.00 [20].

This increase in pH has significance implications for both the preservation and sensory qualities of the jam. The highest pH that is 3.677 in this study was F3 which contains addition of water in the formulation. An increased pH may reduce the efficiency of gel formation using pectin [22] possibly leading to a jam with an unfavourable texture additionally, it may have an impact on the jam's overall quality, flavour, and aroma. [21]. Furthermore, when water is added to jam, it reduces the concentration of organic acids, which can cause the pH to rise due to concentration of  $H^+$  ions decreases and the pH of the solution increases [23].

**Table 2** pH of Red Dragon Fruit Jam

Formulation	Acidity and pH
Control (Sugar + No Honey)	3.357 $\pm$ 0.089 <sup>a</sup>
F1 (Honey + No Sugar)	3.620 $\pm$ 0.010 <sup>bc</sup>
F2 (Honey + Sugar)	3.543 $\pm$ 0.021 <sup>b</sup>
F3 (Honey + Sugar + Water)	3.677 $\pm$ 0.032 <sup>c</sup>

Value was expressed as mean  $\pm$  SD of triplicate determinations. The means with different lowercase letters (a,b, c) in the same column are significantly different at  $p < 0.05$ . Control (Sugar + No Honey), F1 (Honey + No Sugar), F2 (Honey + Sugar), F3 (Honey + Sugar + Water).

### 3.2 Total Soluble Solid (TSS)

Table 3 presented the control formulation, with the highest TSS value (55.73  $\pm$  0.764), reflects the high concentration of sugar, which is highly soluble and significantly boosts TSS levels. This aligns with sugar's role in enhancing sweetness and preserving the jam by reducing water activity. The elevated levels of dissolved sugars in organic acids, and other soluble solids are indicated by the high TSS concentrations in Control [24]. In comparison, F1 (honey-only) had a lower TSS (50.13  $\pm$  1.155) due to the natural sugar composition of honey, which includes a mix of fructose and glucose rather than pure sucrose which Over 80% of honey's total

dissolved solids are sugar, including both glucose and fructose. Although honey contributes to TSS, its lower total sugar content explains this reduction [25].

F2 (honey + sugar) demonstrated a slightly higher TSS ( $51.03 \pm 0.115$ ) than F1, as the combination of honey and sugar balanced the contributions from both sweeteners, enhancing flavour complexity and nutritional value [3]. Meanwhile, F3 (honey + sugar + water) had the lowest TSS ( $41.83 \pm 0.551$ ) because of the dilution effect from added water, which reduced sweetness and overall solids content. These results suggest that the presence of honey affects the TSS levels by introducing sugars with different solubilities, such as fructose and glucose, which may not contribute as heavily to TSS as sucrose in sugar-only formulations.

The slightly lower TSS in honey-based jams indicates a reduction in dissolved solids compared to the control, which could be attributed to the natural composition of honey and its interaction with other ingredients [26]. This aligns with the unique physicochemical properties of honey, where its sugars may be distributed differently due to their natural structure [27]. Despite the moderate TSS values, F2, honey-sugar based jams offer a more balanced sweetness profile and enhanced sensory appeal.

**Table 3** TSS of Red Dragon Fruit Jam

Formulation	Total Soluble Solid (%)
Control (Sugar + No Honey)	$55.73 \pm 0.764^c$
F1 (Honey + No Sugar)	$50.13 \pm 1.155^b$
F2 (Honey + Sugar)	$51.03 \pm 0.115^b$
F3 (Honey + Sugar + Water)	$41.83 \pm 0.551^a$

Value was expressed as mean  $\pm$  SD of triplicate determinations. The means with different lowercase letters (a,b, c) in the same column are significantly different at  $p < 0.05$ . Control (Sugar + No Honey), F1 (Honey + No Sugar), F2 (Honey + Sugar), F3 (Honey + Sugar + Water).

### 3.3 Moisture Content

From the Table 4, we can see that the moisture content of red dragon fruit jam formulations reflects the influence of different sweeteners like sugar, honey, or their combination on water retention and texture. The results ranged from  $40.51 \pm 0.205\%$  in the sugar-only formulation (Control) to  $56.94 \pm 0.087\%$  in the honey + sugar + water formulation (F3). The Control formulation, made solely with sugar, had the lowest moisture content at  $40.51 \pm 0.205\%$ . Sugar functions as a dehydrating agent, binding water molecules and promoting evaporation during cooking, which reduces water activity and leads to a firmer texture [28].

While this low moisture content enhances shelf stability, it may compromise sensory qualities like softness and spreadability, making it less appealing than honey-based formulations. In contrast, F1 (honey-only) exhibited a significantly higher moisture content of  $55.54 \pm 0.465\%$  due to honey's hygroscopic nature, which allows it to attract and retain water [49]. This increase contributes to a softer, smoother texture, enhancing the jam's sensory appeal [29]. However, honey's composition, with a water activity ( $a_w$ ) typically ranging from 0.5–0.65, affects water retention and moisture in the jam. Glucose crystallization in honey can dilute the soluble solids and potentially increase moisture, which could pose challenges for microbial stability [30]. Despite this, it indicates its suitability for jam production [49].

Although sugar effectively lowers water activity by attaching to water molecules, honey-based products generally possess greater moisture levels due to honey's inherent hygroscopic characteristics. This presents a possible danger for microbial activity if the water activity surpasses the stability threshold [30]. The F2 formulation (honey + sugar) had an intermediate moisture content of  $48.34 \pm 1.375\%$ , lower than F1 and F3 but higher than the Control. This reflects the combined effects of sugar's dehydrating properties and honey's moisture-retaining capabilities. By balancing these effects, F2 offers a texture that is both soft and stable, demonstrating that combining sugar with honey can optimize the jam's moisture. F3 (honey + sugar + water) exhibited the highest moisture content at  $56.94 \pm 0.087\%$ , slightly higher than F1. The addition of water in F3 diluted the jam matrix, but the moisture-retaining properties of honey still played a dominant role. Statistical analysis showed no significant difference between F1 and F3, highlighting honey's ability to maintain water retention even with added water.

**Table 4** Moisture Content of Red Dragon Fruit Jam

Formulation	Moisture Content (%)
Control (Sugar + No Honey)	$40.51 \pm 0.205^a$
F1 (Honey + No Sugar)	$55.54 \pm 0.465^c$
F2 (Honey + Sugar)	$48.34 \pm 1.375^b$
F3 (Honey + Sugar + Water)	$56.94 \pm 0.087^c$

Value was expressed as mean ± SD of triplicate determinations. The means with different lowercase letters (a,b, c) in the same column are significantly different at  $p < 0.05$ . Control (Sugar + No Honey), F1 (Honey + No Sugar), F2 (Honey + Sugar), F3 (Honey + Sugar + Water).

### 3.4 Colour

Based on Table 5, the control formulation exhibited the highest lightness value ( $L^* = 42.10 \pm 0.541$ ), giving it a bright and appealing appearance. The  $a^*$  value ( $1.623 \pm 0.155$ ) indicates a subtle red hue, while the  $b^*$  value ( $-4.90 \pm 0.085$ ) reflects a negative blue tint. This balanced colour profile is typical of sugar-based jams, where the natural fruit colour is preserved, enhancing the visual appeal and contributing to consumer satisfaction. Colours have a profound effect on our feelings and perceptions and are essential to visual communication. Because different colours evoke a broad range of emotions and sensations, businesses and designers carefully choose which colours to employ in their branding and marketing strategies [31].

The appropriate hues may draw attention, evoke feelings, and even affect our purchasing decisions [42]. In the honey-only formulation, which is F1, lightness decreased ( $L^* = 39.47 \pm 0.332$ ), resulting in a slightly darker appearance. The higher  $a^*$  value ( $2.543 \pm 0.344$ ) suggests a more intense red tone compared to the control, while the  $b^*$  value ( $-4.14 \pm 0.061$ ) remains negative, indicating a reduced blue or yellow hue. This darker colour can be attributed to the pigments naturally present in honey and its lower water content, which concentrates colours during the cooking process [30] [31] which when heating process, it showed an increase in brown pigment. Brown pigments are created when honey's sugars are condensed with free amino acids in a non-enzymatic browning process. Honey's dark hue and antioxidant activity can both be enhanced via the maillard process [34] [50].

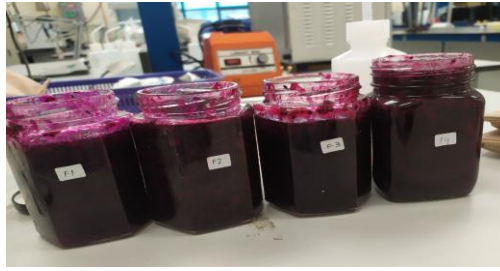
The combination of honey and sugar in F2 resulted in the lowest lightness ( $38.38 \pm 0.341$ ), creating the darkest jam among the formulations. The  $a^*$  value ( $1.420 \pm 0.234$ ) shows reduced red tones compared to F1, while the  $b^*$  value ( $-4.37 \pm 0.530$ ) indicates a slightly stronger negative yellow or blue tint than in F1. This darker appearance may stem from the interaction of honey and sugar during heating, where caramelization and maillard reactions [50] can intensify the overall colour [35]. Moreover, the combination of sugar and honey which honey amounts higher than sugar made it darker too because honey naturally has a golden hue that can deepen the colour of jams, especially when used in larger amounts. Unlike the neutral, colourless appearance of granulated sugar, honey's natural pigments add a richer and warmer tone to the final product, enhancing its visual appeal [36] includes water, exhibiting a lightness value ( $L^* = 40.20 \pm 0.691$ ) higher than F1 and F2 but lower than the control. This suggests that the added water slightly offsets the darkening effects of honey and sugar. The  $a^*$  value ( $1.303 \pm 0.265$ ) reflects consistency in the red hue, comparable to F2, while the  $b^*$  value ( $-4.64 \pm 0.150$ ) indicates a mild shift toward a negative yellow or blue tone. Although the water addition improved brightness, the jam did not fully regain the brightness observed in the control formulation.

Hence, the four jam formulations made from red dragon fruit have much in red colour due to red dragon fruit as their main ingredient. This guarantees the inclusion of betacyanin pigments, which are responsible for the natural red-purple colour in each jam formulation. Furthermore, all the jams exhibited negative  $b^*$  values. While these values do not signify the presence of blue or yellow, they indicate a lack of yellow tones, consistent with the predominance of red-purple hues.

**Table 5** Colour of Red Dragon Fruit Jam

Formulation	Colour		
	L	$a^*$	$b^*$
Control (Sugar + No Honey)	$42.10 \pm 0.541^c$	$1.623 \pm 0.155^a$	$-4.90 \pm 0.085^a$
F1 (Honey + No Sugar)	$39.47 \pm 0.332^{ab}$	$2.543 \pm 0.344^b$	$-4.14 \pm 0.061^b$
F2 (Honey + Sugar)	$38.38 \pm 0.341^a$	$1.420 \pm 0.234^a$	$-4.37 \pm 0.530^{ab}$
F3 (Honey + Sugar + Water)	$40.20 \pm 0.691^b$	$1.303 \pm 0.265^a$	$-4.64 \pm 0.150^{ab}$

Value was expressed as mean ± SD of triplicate determinations. The means with different lowercase letters (a,b, c) in the same column are significantly different at  $p < 0.05$ . Control (Sugar + No Honey), F1 (Honey + No Sugar), F2 (Honey + Sugar), F3 (Honey + Sugar + Water).



**Fig. 1** The dragon fruit jam colour, Control from the left to F3 to the right

### 3.5 Viscosity

Table 6 showed the Control formulation (sugar-only) displayed a viscosity of  $3423.67 \pm 1.528$  cP, consistent with traditional sugar-based jams. In this formulation, sugar interacts with pectin to form a stable gel matrix, yielding a moderately firm texture ideal for spreading, especially when having pectin, sugar molecules will bind to water molecules and enable the pectin to create a gel. If insufficient sugar is added, the pectin will become diluted and will fail to create a gel and reduce the viscosity [37]. However, the absence of honey lowers the viscosity enhancement resulting in a texture that is not too smooth and richness like when that honey provides.

The F1 formulation (honey-only) exhibited the highest viscosity at  $7431.33 \pm 2.517$  cP. This significant increase is attributed to honey's natural viscosity, which is higher than that of sucrose solutions due to its composition, predominantly glucose, fructose, and a lower water content [38]. Additionally, honey's ability to enhance water retention and reinforce gel structure contributes to the dense texture observed [36]. However, while F1's high viscosity aligns with good texture, it may pose challenges for ease of spreading, suggesting a need for formulation adjustments.

The F2 formulation (honey + sugar) recorded a viscosity of  $4324.33 \pm 1.528$  cP, providing a balanced texture between Control and F1. The complementary effects of sugar and honey in this formulation enhance the gel matrix while maintaining smooth and firm consistency. F3 (honey + sugar + water) had the lowest viscosity at  $1002.67 \pm 2.082$  cP, largely due to the addition of water, which diluted the gel matrix and weakened the interactions between pectin, sugars, and honey. While this thinner consistency improves spreadability because Pectin's thickening and gelling properties immobilized by the water in jam [39]. It may be perceived as lower quality, as thicker textures are generally associated with jam in the market. The reduced viscosity in F3 aligns with findings from the European Journal of Agriculture and Food Sciences, which noted that honey's hygroscopic nature can dilute mixtures over time, reducing viscosity further if ambient moisture is absorbed.

The viscosity of jams typically ranges from 1,000 to 10,000 cP (or 1 to 10 Pa·s), depending on the formulation and processing conditions [38]. The viscosities observed in the red dragon fruit jams fall within this range, with F3 (honey + sugar + water) at the lower limit and F1 (honey-only) approaching the upper range. F1's high viscosity aligns with better quality characteristics but risks a texture that may feel overly dense for some consumers. Conversely, F2 offers a well-balanced viscosity that aligns with consumer expectations for spreadable and visually appealing jams.

**Table 6** Viscosity of Red Dragon Fruit Jam

Formulation	Viscosity (cP)
Control (Sugar + No Honey)	$3423.67 \pm 1.528^b$
F1 (Honey + No Sugar)	$7431.33 \pm 2.517^d$
F2 (Honey + Sugar)	$4324.33 \pm 1.528^c$
F3 (Honey + Sugar + Water)	$1002.67 \pm 2.082^a$

Value was expressed as mean  $\pm$  SD of triplicate determinations. The means with different lowercase letters (a,b, c, d) in the same column are significantly different at  $p < 0.05$ . Control (Sugar + No Honey), F1 (Honey + No Sugar), F2 (Honey + Sugar), F3 (Honey + Sugar + Water).

### 3.6 Sensory Properties

Small amounts of each jam sample were provided with bread for the panellists to evaluate. In general, the findings showed no significance differences ( $p > 0.05$ ) between F1, F2, and F3 regarding appearance, colour, texture, flavour, aroma, and overall acceptance. From Table 7, the sensory evaluation of the red dragon fruit jam formulations (F1, F2, and F3) reveals differences and similarities in their characteristics. Among the three, F2 stood out as the most visually appealing, earning the highest score of ( $7.32 \pm 1.889$ ) for appearance. In

comparison, both F1 and F3 received slightly lower but similar scores of ( $6.96 \pm 1.916$ ) and ( $6.96 \pm 2.030$ ), respectively. In sensory evaluations, the visual attributes of food products are crucial, as they can influence perceptions of flavour even before tasting occurs [41]. The appealing appearance of dragon fruit jam can thus enhance its marketability and consumer preference [42].

In terms of colour, all formulations showed strong performance, with F2 standing out as the highest scorer at ( $7.30 \pm 1.810$ ), closely followed by F1 ( $7.18 \pm 1.826$ ) and F3 at ( $7.08 \pm 2.146$ ). The appeal of dragon fruit jam largely stems from its vibrant colour and unique appearance. The natural pigments found in dragon fruit, particularly betacyanins, contribute to its striking red-violet hue, which is visually enticing and can enhance consumer interest [43]. This rich coloration not only makes the jam more attractive but also signals freshness and quality to potential consumers. Research indicates that colour plays a significant role in food acceptance which consumers often associate brighter, more vivid colours with better taste and quality [44].

Aroma, however, emerged as the least favourable attribute across all samples. F2 showed the highest aroma score at ( $6.22 \pm 2.083$ ), followed by (F3 at  $6.00 \pm 2.304$ ), and F1 at ( $5.80 \pm 2.176$ ). The interaction between honey and other ingredients in the jam can also affect aroma perception. For instance, when combined with sugar or water, the balance of flavours and aromas can shift, potentially masking or altering the honey's natural scent [45]. Additionally, the fruit's own aroma contributes to the overall scent profile if the fruit does not have a strong aroma, it may not adequately complement or enhance the honey's fragrance due although not quite as strong as durian, dragon fruit has a pleasingly flowery scent with that distinctive honeyed tropical fruit funk which influenced aroma [46].

Taste was one of the stronger points, with F2 scoring the highest at ( $7.02 \pm 2.055$ ), showcasing a well-balanced flavour profile. F1 and F3 trailed slightly behind with scores of ( $6.52 \pm 2.073$ ) and ( $6.44 \pm 2.314$ ), respectively. Taste is often the most important factor for consumers when selecting food products. Studies show that approximately 85% of consumers prioritize taste over other attributes such as price, health benefits, or convenience [47]. A product that tastes good is more likely to be chosen.

In terms of texture, F2 again led with a score of ( $7.00 \pm 2.020$ ), while F1 and F3 received slightly lower scores of ( $6.58 \pm 2.021$ ) and ( $6.48 \pm 2.270$ ), indicating minor differences in mouthfeel among the formulations. Texture plays a crucial role in how consumers evaluate food products. A desirable texture enhances the overall eating experience, making the jam more enjoyable to spread and consume. Jams that are too runny may be perceived as low-quality, while those that are too thick can be difficult to spread. A well-balanced texture contributes to a positive sensory experience, leading to higher consumer satisfaction [48].

Overall acceptability mirrored these trends, with F2 achieving the highest score of ( $7.14 \pm 1.969$ ), reflecting its overall balance across all evaluated attributes. F1 was rated moderately well at ( $6.84 \pm 1.856$ ), whereas F3 had the lowest overall acceptability score of ( $6.60 \pm 2.204$ ). These findings suggest that while F2 is the most favoured formulation.

**Table 7** Sensory Properties of Red Dragon Fruit Jam

Sensory attributes	Formulation		
	F1 (135)	F2 (145)	F3 (155)
Appearance	$6.96 \pm 1.916^a$	$7.32 \pm 1.889^a$	$6.96 \pm 2.030^a$
Colour	$7.18 \pm 1.826^a$	$7.30 \pm 1.810^a$	$7.08 \pm 2.146^a$
Aroma	$5.80 \pm 2.176^a$	$6.22 \pm 2.083^a$	$6.00 \pm 2.304^a$
Taste	$6.52 \pm 2.073^a$	$7.02 \pm 2.055^a$	$6.44 \pm 2.314^a$
Texture	$6.58 \pm 2.021^a$	$7.00 \pm 2.020^a$	$6.48 \pm 2.270^a$
Overall Acceptances	$6.84 \pm 1.856^a$	$7.14 \pm 1.969^a$	$6.60 \pm 2.204^a$

Value was expressed as mean  $\pm$  SD of triplicate determinations. The means with different lowercase letters (a) in the same column are significantly different at  $p < 0.05$ . Control (Sugar + No Honey), F1 (Honey + No Sugar), F2 (Honey + Sugar), F3 (Honey + Sugar + Water).

#### 4. Conclusion

Overall, this research demonstrates that red dragon fruit jam can be successfully formulated with honey as a natural sweetener. The objectives achieved that the panellists accept of the jam based on overall acceptances in 9-hedonic test and among the formulations, F2 (honey + sugar) met the objectives of maintaining physicochemical stability and consumer appeal. Partially substituting honey and sugar in red dragon fruit jam formulation effectively reduced the overall table sugar content while enhancing the sensory properties, particularly flavour and texture. The combination of honey with dragon fruit yielded a jam that maintained a

desirable consistency comparable to traditional sugar-based jams. Complete substitution with honey did not significantly alter the texture, ensuring that the product remained appealing to consumers. The physicochemical analysis revealed that honey contributed to maintaining the jam's pH and moisture levels, which are critical for gel formation and overall stability. The results indicate that using honey as a sweetener can positively influence the jam's viscosity and spreadability. These are essential attributes for consumer satisfaction. Overall, this research demonstrates that red dragon fruit jam can be successfully formulated with honey as a natural sweetener without compromising its textural qualities. The recommendation for improvements that can be made in future is that a detailed nutritional analysis could be carried out to highlight the health benefits of red dragon fruit and honey, appealing to health-conscious consumers. Emphasizing antioxidant properties and potential functional benefit. Next, shelf-life study through various storage conditions, including temperature and humidity levels. Lastly, conducting microbial tests is essential to evaluate the safety of the jam. This includes testing for common foodborne pathogens such as Salmonella, E. coli, and molds that can thrive in high-moisture environments.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Nur Daleena Mastura Saiful Bharin, Fazleen Izzany Abu Bakar; **data collection:** Nur Daleena Mastura Saiful Bharin; **analysis and interpretation of results:** Nur Daleena Mastura Saiful Bharin; **draft manuscript preparation:** Nur Daleena Mastura Saiful Bharin. All authors reviewed the results and approved the final version of the manuscripts.*

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