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Organoleptic Study of Red Dragon Fruit Jam (*Hylocereus polyrhizus*) from the Perspective of Statistics and Food Chemistry

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Abstract. Red dragon fruit *(Hylocereus polyrhizus)* based jam products have high potential, but consumer acceptance is still limited due to sensory constraints that arise when dragon fruit skin is used as an additional ingredient. This study aimed to evaluate the sensory quality of red dragon fruit jam by adding dragon fruit peel, using statistical and food chemistry approaches. Organoleptic tests were conducted on 30 untrained panellists to assess four main attributes: colour, texture, odour, and taste, using a 9-point hedonic scale. Data were analyzed using descriptive statistics, the Shapiro-Wilk normality test, the one-sample t-test, and cronbach's alpha reliability test. The results showed that colour and texture were not significantly different from the "like" threshold value ($\mu = 7$), while odour and taste showed significant differences ($p < 0.05$). Cronbach's alpha value of 0.673 indicated moderate consistency of assessment. The food chemistry perspective explain that the less preferred odour and taste attributes are thought to be caused by secondary metabolite compounds such as tannins in dragon fruit peel, which can produce a bitter sensation or foreign odour. Approaches such as blanching and formulation adjustments can be strategies to improve sensory quality. This study contributes to developing innovative and sustainable dragon fruit-based food products.
Keywords: dragon fruit jam; dragon fruit peel; organoleptic test; food chemistry; statistical analysis

Introduction

Red dragon fruit *(Hylocereus polyrhizus)* is known to have various health benefits due to its nutritional content, which is rich in vitamin C, fiber, and antioxidants (Aryanta, 2022). As public awareness of the importance of fruit consumption increases (Safitri et al., 2023), demand for dragon fruit in Indonesia continues to increase (Hartono et al., 2025). However, this fruit has a relatively short shelf life, requiring processing innovations to extend its shelf life while maintaining its economic value. One widely developed processed form is jam, which not only extends shelf life but also increases the product's added value (Lestari et al., 2023).

Dragon fruit jam is generally made solely from the fruit's flesh. Several previous studies have focused on organoleptic aspects and specific chemical characteristics, such as antioxidant content (Laswatin, 2020), pH (Bintang et al., 2022), and moisture content (Arsyad & Riska, 2021). However, the dragon fruit peel, often considered waste, has received less attention, despite previous studies on its use demonstrating its extensive bioactive and functional potential.

In vivo test results showed that administration of 5% (w/w) dragon fruit peel powder was able to reduce liver malondialdehyde (MDA) levels by up to 32% and increase superoxide dismutase (SOD) activity by 28% in mice on a high-fat and fructose diet (Chumroenvidhayakul et al., 2025). In terms of functional food properties, substitution of 5% dragon fruit peel powder was shown to reduce the in vitro glycemic index by up to 12% while increasing total antioxidant capacity by 22% (Chumroenvidhayakul et al., 2023). In addition, the use of dragon fruit peel in combination with other ingredients, such as soursop, resulted in a 25% increase in vitamin C and a more attractive color (Primaviera et al., 2024). Processing red dragon fruit peel (50%) with pumpkin with the addition of carrageenan was also reported to significantly increase antioxidant activity (Suparno et al., 2022).

Meanwhile, research on processed food products shows an increase in nutritional quality as well as sensory acceptance. Substitution of up to 20% dragon fruit peel in jelly formulation increases the total phenolic content by 40% compared to the control, with the panelists' preference level remaining in the "like" category (P et al., 2025). The addition of 30% red dragon fruit peel to jam has been shown to increase vitamin C levels to 18.4 mg/100 g compared to 12.6 mg/100 g in the control, without reducing panelists' acceptance of color and taste (Amanda & Iswendi, 2025). Even in modern products, fortifying cookies with up to 10% dragon fruit peel powder can increase the crude fiber content from 1.8 to 3.4% and increase the total phenolic content by 45%, with consumer acceptance scores remaining high (an average of 8 on a scale of 9) (Akter et al., 2025).

Although various studies demonstrate the functional potential of dragon fruit peel, most involve complex formulation variations, making it difficult to isolate the sole effect of dragon fruit peel. Combinations with other ingredients, such as pumpkin and carrageenan, have resulted in increased antioxidant activity, but the contribution of dragon fruit peel cannot be separated (Suparno et al., 2022). Variations in red dragon fruit peel concentrations of 10, 20, and 30% have also been reported to simultaneously affect pH, water content, vitamin C, and sensory quality (Amanda & Iswendi, 2025). Furthermore, variations in mixtures with soursop fruit provide increased vitamin C content and a more attractive color (Primaviera et al., 2024). In cookie products, the use of dragon fruit peel powder in various concentrations has been shown to lower the glycemic index and increase fiber and total phenolic content, although the final result is still influenced by dough composition (Akter et al., 2025; Chumroenvidhayakul et al., 2023).

Therefore, this study focused on a single basic formulation with the addition of red dragon fruit peel as a single variable, allowing for a more in-depth study of its effects on sensory characteristics. Organoleptic tests were conducted on colour, odour, taste, and texture attributes, with statistical analysis to obtain an objective picture of the product's acceptability. From a food chemistry perspective, this approach also allows for a scientific explanation of the sensory test results by linking them to the bioactive components of dragon fruit peel, thus providing a comprehensive understanding of its contribution to the final quality of the jam product. Accordingly, the aim of this study was to evaluate the effect of red dragon fruit peel addition on the sensory acceptability of jam and to provide a food chemistry-based interpretation of the observed characteristics.

Methods

The main ingredients used in this study include red dragon fruit flesh and peel, granulated sugar (Gulaku), commercial pectin, and drinking water (Club). All ingredients were obtained from traditional markets in Bantaeng, South Sulawesi, Indonesia. The instruments used in this study included a blender (Philips), a stainless-steel pan, a gas stove (Rinnai), a digital kitchen scale (Elec, accuracy ±1 g), a food grade plastic bottle, a 9-scale sensory evaluation sheet according to SNI 01-2346-2006, and IBM SPSS statistics® version 25 statistical software.

Dragon fruit jam is made by mixing 700 g of red dragon fruit flesh, 50 g of red dragon fruit peel, 300 g of granulated sugar, 1 g of commercial pectin, and 100 mL of boiled water, using a blender. The mixture is then cooked in a stainless-steel pan on a gas stove over low heat (±90°C), stirring until it thickens and reaches the typical jam consistency. Once cooked, the jam is cooled to room temperature and packaged in clean and dry food-grade plastic bottles.

The panel was selected using a random sampling method with 30 untrained panelists. Inclusion criteria included being 18–35 years old, not allergic to dragon fruit, and willing to participate in organoleptic testing. Each panelist received a different randomly coded sample for each product and was asked to assess the jam products based on four sensory attributes: colour, texture, odour, and taste. The evaluation was conducted individually without discussion to avoid subjective influences between individuals (Das et al., 2025).

Sensory assessment was conducted using a 9-scale hedonic test based on SNI 01-2346-2006, covering the attributes of color, texture, aroma, and taste. The scale ranged from (1) remarkably immensely dislike, (2) immensely dislike, (3) dislike, (4) somewhat dislike, (5) neutral, (6) somewhat like, (7) like, (8) very like, and (9) remarkably like (Badan Standarisasi Nasional, 2006). Each panelist filled in their identity, test date, and sample code, then gave a score for each attribute. Testing was conducted in a room with good ventilation, adequate lighting, and a constant temperature (±25°C) to minimize environmental disturbances. Panelists were also given mineral water to rinse their mouths between samples.

Organoleptic test result data were analysed through several stages as follows:

a. Descriptive statistics

The mean, standard deviation, median, maximum, and minimum values for each attribute (colour, texture, odour, and taste) were analyzed to provide a general overview of panelists' perceptions of the dragon fruit jam product.

b. Normality test (shapiro-wilk)

The shapiro-wilk test is used to test the normality of the data to determine whether the assessment data is normally distributed (Ismail, 2022). This test is performed for all assessed attributes. The steps for the normality test are implemented in a sequence of procedures. First, establishing the hypothesis, which H_0 (null hypothesis): the data is normally distributed and H_1 (alternative hypothesis): the data is not normally distributed. Second, calculate the shapiro-wilk value using equation 1.

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (1)$$

remark:

W = shapiro-wilk test statistic

a_i = a coefficient dependent on the sample size n, calculated using the covariance matrix of the sorted normal samples

$x_{(i)}$ = the sorted sample data

x_i = the individual sample value

$\bar{x}$ = the sample mean

Lastly, comparing the P-value with alpha, which is below the category.

- If the p-value > $\alpha\,(0.05)$, then accept H_0 (the data is considered normally distributed).
- If the p-value < $\alpha\,(0.05)$, then reject H_0 (the data is considered not normally distributed).

c. One-sample t-test

If the data are normally distributed, a one-sample t-test is performed to test whether the average of a sample of panelists' ratings differs significantly from a certain threshold value (the known population mean) (Ismail, 2022). A score of 7 on the Likert scale indicates "like," which is a fairly strong positive standard without being too extreme. Using μ=7 allows us to test whether the panelists' ratings align with the expectation that the product is generally liked.

The steps for the one-sample t-test are implemented in a sequence of procedures. First, establishing the hypothesis, which H_0 (null hypothesis): $\bar{X} = \mu$ (the sample mean is equal to the population mean) and H_1 (alternative hypothesis): $\bar{X} \neq \mu$ (the sample mean is different from the population mean). Second, calculate the one-sample t-test statistic using equation 2.

$$t = \frac{\bar{\bar{X}} - \mu}{\frac{s}{\sqrt{n}}} \quad (2)$$

remark:

$\bar{X}$ = the sample mean
μ = the hypothesized population mean
S = the sample standard deviation
n = the sample size

Third, determine the degrees of freedom (df) used $df = n - 1$. Fourth, determine the critical t-value and significance level (α), then compare the calculated t-value with the critical t-value from the t-distribution table for a given significance level (α) and degrees of freedom. Lastly, comparing the calculated t-value with the critical t-value, which is below the category.

- If the calculated t-value > the critical t-value, reject H_0 (the sample mean is significantly different from the population mean).
- If the calculated t-value < the critical t-value, accept H_0 (there is no significant difference).

d. Reliability test (cronbach's alpha)

The reliability of panelist assessments was tested using cronbach's alpha (Anggraini et al., 2022; Pentapati et al., 2025). Its value ranges from 0 to 1, with a value <0.50 indicating low reliability, a value <0.50 and a value <0.70 indicating moderate reliability, an alpha >0.70 indicating sufficient reliability, an alpha >0.80 indicating strong reliability, and an alpha >0.90 indicating perfect reliability (Slamet & Wahyuningsih, 2022). The formula for the reliability test is shown in equation 3.

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum \sigma_{item}^2}{\sigma_{total}^2}\right) \quad (3)$$

remark:

α = cronbach's alpha (reliability value)
N = the number of items (attributes or variables being measured)
σ_{item}^2 = the variance for each item
σ_{total}^2 = the total variance of the overall score

e. Sensory attribute analysis from a food chemistry perspective

A qualitative analysis based on literature from a food chemistry perspective was conducted to explain the relationship between the chemical characteristics of ingredients and sensory perception and gain a more comprehensive understanding of product quality.

Results and Discussion

The results of the hedonic test of dragon fruit jam can be seen in Table 1. The assessments showed variations in perception among panelists, reflecting individual preferences for the sensory characteristics of the dragon fruit jam. Most assessments tended to be close to the "like" category (7), but there were several assessments that were in the neutral (5) or even "dislike" category (3), especially for the odour and taste attributes. This indicates different perceptions among panelists, which is important for further analysis to understand consumer acceptance of this product.

Table 1. Dragon fruit jam assessment by panelists

Panelists	Colour	Texture	Odour	Taste	Panelists	Colour	Texture	Odour	Taste
Panelist 1	7	9	9	9	Panelist 16	7	5	4	8
Panelist 2	5	6	2	4	Panelist 17	8	5	4	4
Panelist 3	7	6	4	7	Panelist 18	9	8	5	7
Panelist 4	8	6	5	7	Panelist 19	7	9	8	9
Panelist 5	7	8	3	7	Panelist 20	5	3	4	5
Panelist 6	6	7	4	5	Panelist 21	8	8	7	7
Panelist 7	6	5	6	5	Panelist 22	6	6	5	4
Panelist 8	8	6	5	7	Panelist 23	9	6	3	8
Panelist 9	6	7	8	6	Panelist 24	5	5	4	6
Panelist 10	7	7	4	4	Panelist 25	4	7	5	7
Panelist 11	5	4	3	6	Panelist 26	9	8	3	3
Panelist 12	6	7	7	5	Panelist 27	8	5	6	7
Panelist 13	5	7	4	5	Panelist 28	7	8	6	7
Panelist 14	4	5	5	4	Panelist 29	8	7	5	6
Panelist 15	9	7	6	7	Panelist 30	7	8	6	9

Descriptive statistical analysis provides an overview of the panellists' assessment tendencies, as shown in Table 2. The mean ratings for colour and texture were above 6.5, approaching the "like" level on the Likert scale, with similar median values. The standard deviation for each attribute ranged from 1.46 to 1.66, indicating some variation in assessments among panellists. The odour attribute had the lowest mean rating (5), suggesting that this attribute had a more neutral rating than the other qualities. The maximum (9) and minimum (2-3) scores recorded for each attribute indicate that panellists either strongly liked or disliked the dragon fruit jam based on that attribute.

Table 2. Descriptive statistical analysis on panellist assessment of dragon fruit jam

Descriptive Statistics	Dragon Fruit Jam Evaluation Parameters			
	Colour	Texture	Odour	Taste
Average	6.77	6.5	5	6.17
Standard Deviation	1.48	1.46	1.66	1.64
Median	7	7	5	6.5
Maximum Score	9	9	9	9
Minimum Score	4	3	2	3

The assessment of the odour attribute in the jam produced showed the lowest results compared to the other three sensory attributes, both in terms of average (5.00), standard deviation (1.66), median (5), and minimum value (2). Similar findings were also reported in another study (Arsyad & Riska, 2021), where panellists gave higher scores to the odour of dragon fruit jam that did not contain dragon fruit peel. This confirms that selecting the right raw materials and formulations is essential in determining consumer sensory acceptance, especially for odour attributes.

The normality test was conducted using the Shapiro-Wilk method to ensure that the assessment data for each sensory attribute met the assumption of a normal distribution. The test results showed that the four attributes analysed, colour, texture, odour, and taste, had a p-value> 0.05. This indicates that the data distribution of each attribute is normal and meets the requirements for use in parametric statistical analysis, such as the one-sample t-test. In detail, the colour attribute has a Shapiro-Wilk statistical value of 0.934 (p-value 0.064), while the texture attribute shows a value of 0.948 (p-value 0.151). The odour attribute obtained a value of 0.946 (p-value 0.129), and the taste attribute had a value of 0.934 (p-value 0.064). All four p-values are greater than 0.05, indicating that the distribution of panellists' assessments of each attribute does not deviate significantly from the normal distribution.

A similar approach has also been applied in several previous studies which emphasised the importance of normality testing in sensory data analysis to ensure the feasibility of using parametric methods (Waimaleongora-ek & Prinyawiwatkul, 2021). It was stated that hedonic data obtained from enough panelists, especially when using a 9-point scale, generally followed a normal distribution. This finding is supported by another study which showed that normal distribution tends to be achieved in sensory testing, so that parametric statistical analysis can be applied validly (Rosa & Masala, 2023). Thus, this study's results align with previous literature and support data reliability in the sensory evaluation process.

One-sample t-test was conducted to determine whether the average panellist assessment of sensory attributes differed significantly from the threshold value of acceptance, which was a score of 7 on the hedonic scale representing the "like" category. The analysis showed that two attributes, colour and texture, did not show significant differences from these values, with p values of 0.394 for colour and 0.070 for texture (p> 0.05), respectively. This indicates that the panellist's assessment of these two attributes followed the expected preference level. In contrast, the other two attributes, namely odour and taste, showed significant differences from the threshold value. The odour attribute had a minimal p value of 3.15×10^{-7}, while the taste attribute had a p value of 0.009, both of which were less than 0.05. This indicates that the panellist assessment of the odour and taste of dragon fruit jam was below the "like" category, so there is still room for improvement in both aspects.

This result is in line with previous research (Arsyad & Riska, 2021), which showed that panellists preferred jam with a darker colour. The darker colour was produced from the higher percentage of dragon fruit peel addition compared to other variations, with the same amount of fruit flesh in each formulation. Colour is often associated with the freshness and quality of raw materials, thus contributing positively to the overall acceptance level of the product.

Reliability test using cronbach's alpha was conducted to assess the consistency of panellist assessments of the sensory attributes of dragon fruit jam. Cronbach’s alpha value obtained was 0.673. This value indicates a relatively good level of reliability, although it has not reached a high reliability category. In general, values above 0.7 are considered quite acceptable, while values above 0.8 are considered to indicate very good consistency (Izah et al., 2024). These results indicate that panellist assessments are consistent and uniform for the attributes tested. This consistency supports the validity of the sensory assessment data collected, allowing for an adequate confidence level in interpreting consumer preferences for dragon fruit jam products.

The results of the sensory attribute assessment of dragon fruit jam products showed that the colour and texture attributes obtained an evaluation that was not significantly different from the "like" threshold value ($\mu = 7$). In contrast, the odour and taste attributes showed significant differences. These findings were further analysed through a food chemistry approach, especially related to the chemical properties of the ingredients and their interactions during the processing.

The colour attribute that received a positive response from the panellists can be associated with the content of natural pigment compounds in red dragon fruit, namely betacyanin, which is part of the betalain group (Martinez et al., 2024). Betanin, the major component of betacyanin, plays a key role in producing the purplish-red colour. The structure of betacyanin can be observed in Figure 1. This compound is known to be relatively stable under moderately acidic conditions. Betacyanin demonstrates optimal colour retention at pH levels between 4 and 7 and temperatures below 90°C (López-Solórzano et al., 2025).

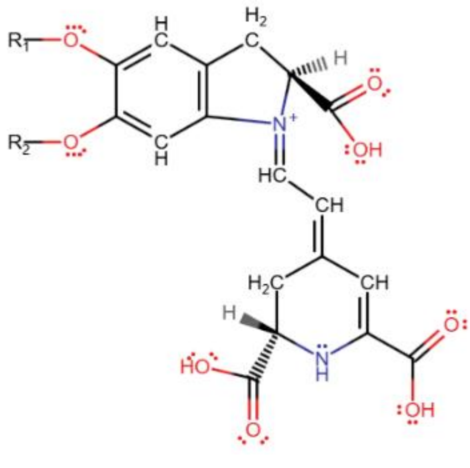

Figure 1. The structural framework of betacyanins, with R1 and R2 representing either hydrogen atoms or sugar groups (Sadowska-Bartosz & Bartosz, 2021)

During mild thermal processing such as pasteurisation at 80°C for 5 minutes, the degradation of betacyanin is minimal, with pigment loss reported to be less than 10% (Chandran et al., 2014). When degradation does occur, the reaction typically involves dehydrogenation and decarboxylation, resulting in colourless or yellowish compounds, as illustrated in the following reaction in Figure 2. The retention of a bright purplish colour suggests that the processing temperature remained within the safe range for maintaining betacyanin stability. Additionally, the inclusion of dragon fruit peel, which also contains betacyanin pigments, likely contributed to increased pigment concentration and enhanced colour intensity in the final product (Fathordoobady et al., 2021).

Texture attributes received positive responses from panellists, with average values not showing significant differences from the acceptance threshold (μ = 7). Jam's texture characteristics are influenced by the gel formation process involving interactions between pectin and sugar and the influence of fruit acidity. Sugar plays a role in forming a pectin network that can trap water, resulting in a gel consistency when the mixture is cooled (Said et al., 2023). Dragon fruit's natural acidity, mostly from citric acid, also supports the gelation process by creating low pH conditions optimal for pectin activity in forming a gel network.

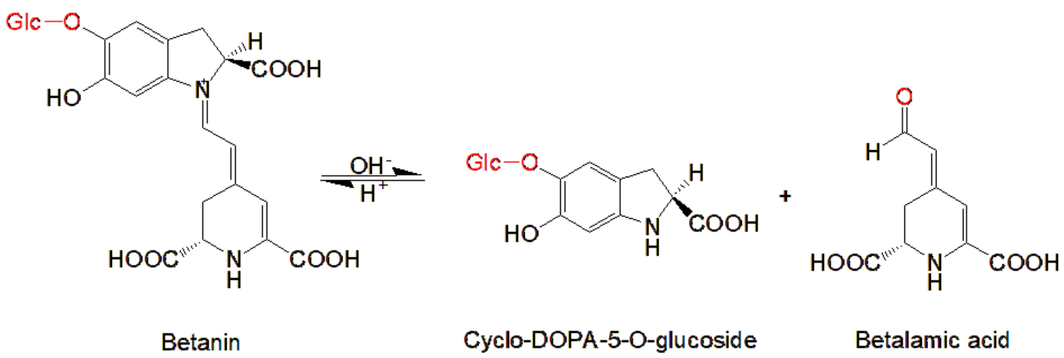

Figure 2. Degradation reaction of betanin, the main pigment in the betacyanin group (Kumorkiewicz-Jamro et al., 2021)

Figure 3 illustrates the transformation process of pectin from powder to gel through four stages: (1) Wetting and swelling, where dry pectin particles begin to absorb water and enlarge; (2) Hydration, where water molecules penetrate deeper and activate the hydrophilic groups on the pectin; (3) Dissolution, where hydrated pectin is dispersed into the solution in the form of polymer chains; and (4) Gelation, which is the formation of a three-dimensional network by the dissolved pectin chains to permanently bind water (Bai & Gilbert, 2022). This diagram also shows the proportional ratio at the bottom, which illustrates the increase in water relative to pectin during the process. Water plays a vital role in each stage of this transformation.

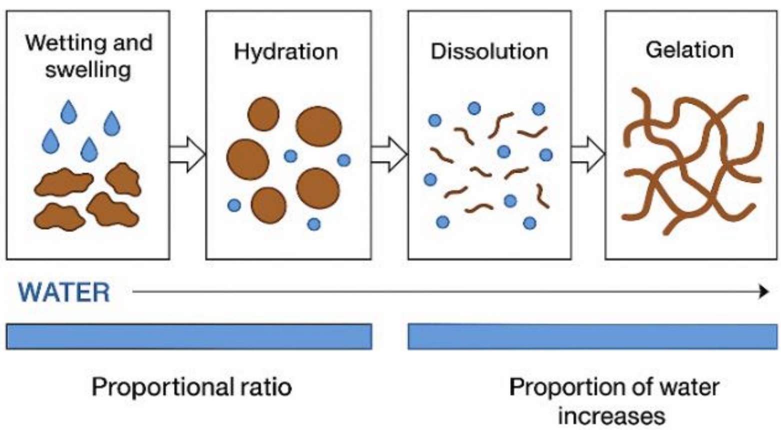

Figure 3. Pectin gelation mechanism

Figure 4 shows the gel formation mechanism of high-methoxyl pectin (HMP). In this type of pectin, the gel is formed through a combination of hydrophobic interactions and hydrogen bonds between pectin chains. The red circles in the figure mark the locations where hydrogen bonds between pectin chains form, which play an essential role in forming junction zones as the foundation of the three-dimensional network of the gel. This gel formation generally occurs at low pH (around 2.5–3.5) and high sugar concentration (55–75%), which helps reduce water activity and allows interactions between pectin molecules to occur more effectively (Said et al., 2023).

The formulation used in this study showed that the combination of pectin, sugar, and acid from dragon fruit was quite effective in producing a texture that matched the characteristics of the jam product. In addition, the presence of fibre from dragon fruit peel contributed to increased viscosity, which could strengthen panellists' perception of texture during organoleptic tests.

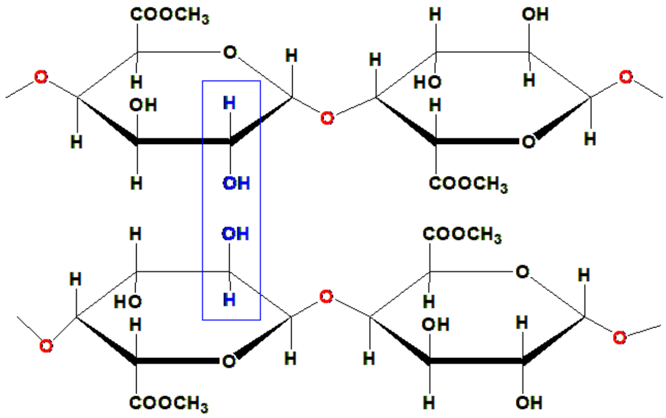

Figure 4. Gelling process of high-methoxyl pectin, with blue box indicating the locations where hydrogen bonds form between pectin chains (Said et al., 2023)

The taste attribute had significantly lower ratings. This is due to the presence of secondary metabolite compounds in dragon fruit peel, such as tannins (Sunani & Hendriani, 2023), which can produce a bitter, sour, or astringent odour or taste sensation (Rosulva et al., 2021). The structure of tannin can be observed in Figure 5. These compounds are **thermolabile** and may undergo **oxidation, hydrolysis, or condensation reactions** during heating, producing degradation products that contribute to undesirable flavour characteristics (Tanaka, 2025).

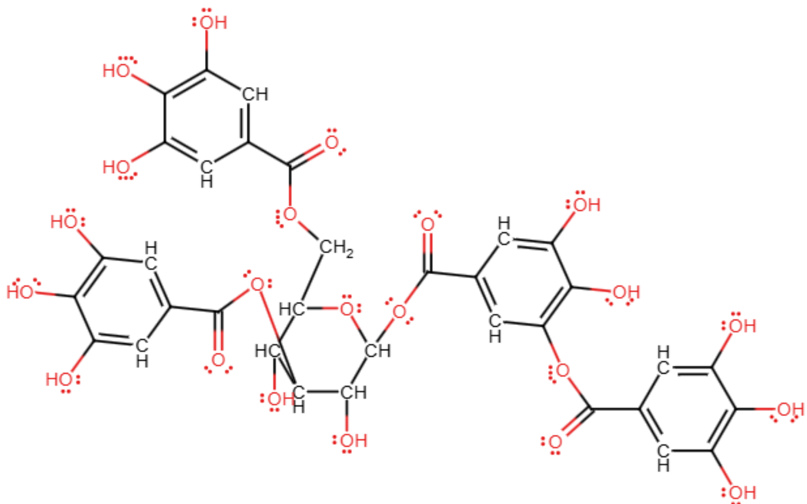

Figure 5. Tannin (Hidjrawan, 2018)

One of the key mechanisms contributing to **astringency** is the **interaction between tannins and salivary proteins**, particularly proline-rich proteins (PRPs), through **hydrogen bonding and hydrophobic interactions**, as shown in Figure 6. This interaction causes **precipitation of salivary proteins**, leading to a dry, rough, or puckering mouthfeel, which negatively affects taste perception and can result in a sensation that is often described as "unpleasant" or "off" by panellists.

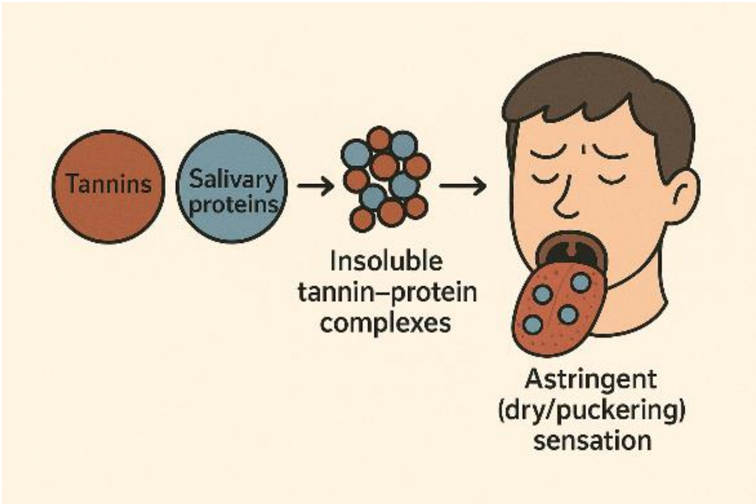

Figure 6. Astringency mechanism in the oral cavity

In addition, prolonged heating can reduce the concentration of positive odour compounds—such as esters and aldehydes—naturally found in dragon fruit flesh. This thermal degradation and volatilisation diminishes fruity or floral notes and weakens the overall aromatic profile (ElGamal et al., 2023). One of the main thermal reactions during fruit processing is caramelisation, which involves the decomposition of sugars at high temperatures without the involvement of amino acids. While caramelisation can contribute to colour development and produce pleasant sweet or nutty notes, excessive heating can accelerate the loss of volatile odour compounds originally present in the fruit. As a result, the product may lose its characteristic fruity odour, leading to a weaker overall odour impression. General caramelisation reaction is shown in Figure 7.

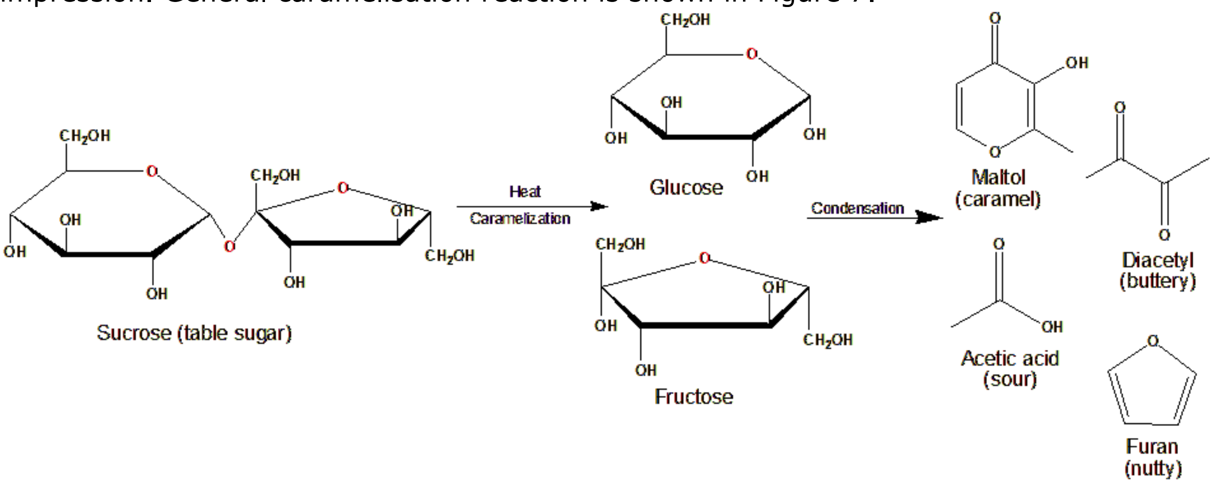

Figure 7. Caramelisation reaction mechanism of sugars at elevated temperature (Choudhary et al., 2021)

For further chemical validation, analytical techniques such as HPLC or GC-MS could be used in future studies to map changes in bioactive compounds during processing. Such chemical profiling would enrich the understanding of how ingredient composition affects the organoleptic outcome, contributing deeper insights for food chemists and product developers.

Overall, from a food chemistry perspective, the results of sensory assessment reflect the complex interactions between the chemical composition of the ingredients, processing treatments, and consumer perceptions. Optimising formulations and processing techniques can help improve odour and taste attributes. One approach that can be applied is pre-treatment, such as blanching of dragon fruit peel, which reduces the content of compounds that cause unpleasant odours or bitter tastes. Blanching is an initial heat treatment process, usually through boiling or steaming for a short time, followed by rapid cooling. The main goal is to inactivate destructive enzymes, soften tissues, and reduce secondary metabolite compounds such as tannins, which are known to produce astringent or off-flavour sensations (Sabahannur et al., 2023). Additionally, adjusting the sugar ratio or adding natural flavours can potentially improve the final product's taste profile.

Conclusion

This study shows that red dragon fruit jam with the addition of dragon fruit peel has a relatively good level of acceptance in terms of colour and texture, with values that are not significantly different from the "like" threshold. However, the odour and taste attributes still show significant differences, indicating room for improvement in terms of formulation and process. The food chemistry approach reveals that volatile compounds and secondary metabolites from dragon fruit peel, such as tannins, can potentially contribute to bitterness and off-flavours, especially after heating. Techniques such as blanching and adjustment of formulation composition can be used to reduce these adverse effects.

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