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Physicochemical and Sensory Evaluation of Ripe Banana Jam Products

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Abstract

Bananas are one of the most extensively consumed fruits in the world due to their unique taste, dietary value, and versatility. The main ingredient in the production of banana jams is banana, sugar, and pectin. The objective of this study is to evaluate sensory characteristics of ripe banana jam from *Musa acuminata* and *Musa paradisiaca* as well as to examine the physicochemical properties of ripe banana jam from *Musa acuminata* and *Musa paradisiaca*. Physicochemical analysis that was carried out in this study are colour analysis, total soluble solids analysis, ash percentage analysis, pH analysis, moisture analysis, viscosity analysis, and texture analysis. From the results, total soluble solids were found to be in the range between 60 to 66% Brix, with ash content of 2.31% for *M. acuminata* and 1.06% for *M. paradisiaca*, pH value ranges between 3.5 to 4.2. The moisture content means for both samples, *M. acuminata* and *M. paradisiaca* are 33.8 and 27.95, respectively, with findings of texture reading that include hardness at range of 58.0 to 67.0 and stickiness at range of -40 to -50. It is summarised from the results of the physicochemical study and sensory evaluation that *Musa acuminata* jam has been found to be more preferable compared to *Musa paradisiaca* jam. The outcomes of this study enhance understanding of the variables that affect jam quality, which presents potential for improving processing methods and satisfying consumer demands. The food sector may benefit greatly from this research, which will direct future efforts towards maximising banana jam production and might generate innovative ideas to increase the attractiveness of these popular fruit preserves.

1. Introduction

Bananas are one of the fruits that are consumed worldwide due to their distinct flavour, nutritional value, and adaptability. Bananas provide a good source of soluble fibre, vitamin B6, also moderately high in potassium, manganese, and vitamin C [1]. Factors that should be considered when selecting the optimal banana variety are taste, sweetness or sourness level, and pulp consistency. The addition of pectin to the jam is one of the methods to obtain a suitable-textured jam as an end product that meets the characteristics of jam.

This study was conducted for the purpose of considering that there are not many sweet and sour options banana jams available in our local market. Customers have limited choices because there is not much supply of both sweet and sour products in the current market. There are previous study states the jam that was in the middle of the sourness range (moderately sour) was preferred rather than extremely sweet or extremely sour [2]. The production of banana jam from *M. paradisiaca* intends to make a little change in the taste of jams involving a certain level of sour-tasting jams for sour likers out there to lessen blandly sweet flavour jams since jams are typically sweet in flavour.

Sensory evaluation investigates which type of banana is most preferred by the consumers. Food goods that satisfy consumer needs will give the food manufacturing sector inspiration and chances to develop more creative food products in the future. Thus, the goal of this study was to evaluate the physicochemical properties and overall acceptance of the two varieties of banana jams.

Examining other relevant studies in this field, an important contribution comes from Abd *et al*. (2021), whose recent findings emphasise the pivotal role of pectin addition in achieving the desired textures of banana jams. It delves into the complex interplay between pectin, a common additive, and its impact on the overall texture of jams [3]. Their emphasis on this aspect aligns seamlessly with this study's exploration of the use of pectin to attain optimal texture in banana jams. Additionally, a comparison with other studies made by Muresan *et al.,* (2014) shows that consumer acceptance depends on a balance between sourness and sweetness, which highlights the importance of this research's goal of assessing the physicochemical characteristics and overall acceptance of banana jams made from *Musa acuminata* and *Musa paradisiaca* [4]

2. Materials and Methods

2.1 Materials

Musa acuminata and *Musa paradisiaca* were purchased from local fruit store near Bukit Rambai, Melaka. Fine granulated sugar was purchased at the nearest supermarket, while pectin, citric acid, and sodium metabisulphite were purchased from online store (Shopee).

2.2 Methods

2.2.1 Preparation of Musa acuminata and Musa paradisiaca jam

To make a banana jam, the banana was peeled, cut into slices, and the blanching treatment was done in 80°C boiling water for 10 minutes. 500 mL of water was used for each 500 g of banana. Then, the blanched banana was cooked with sucrose until it reached 43°C. The heat was taken off from the banana when soluble solids achieved 63 °Brix and pectin was added to the mixture and continuously stirred until a homogenous mixture was formed. The heat was turned on again and the stirring step continued until the temperature reached almost 105°C. Citric acid was added and continued stirring until the temperature reached 105°C. Glass jar was filled with banana jam and immediately pasteurized for 3 to 4 minutes (5]. The jam was allowed to cool first and stored at room temperature. The physicochemical and sensory analysis was interpreted using statistical analysis.

2.2.2 Sensory Evaluation

A group of 60 panellists, participated in the sensory test that was conducted. The panellists were asked to rank their likes or dislikes for banana jams (*M. acuminata* and *M. paradisiaca*) according to characteristics such as colour, flavour, aroma, and texture. The panellists were served room-temperature plain bread and the jams. To reduce the possibility of taste interference, participants were instructed to rinse their mouths before to starting the evaluation and in between each sample's assessment. A 7-point hedonic scale was then given to the panellists to evaluate the banana jams.

2.2.3 Colour analysis

The banana sample was carefully set under the spectrophotometer's head to assess detectable colour differences. The colour analysis process entailed measuring absorbance at a particular light wavelength. The CIE (L*, a*, b*) system is used to convey the findings. L* stands for brightness, a* for redness or greenness, and b* for yellowness or blueness [6].

2.2.4 Total soluble solids content analysis

A refractometer was used to measure the jams' total soluble solid content. Samples were dropped into a refractometer's detector to analyse total soluble solids (TSS). Refraction is the oblique movement of a light beam between two media as a result of variations in the medium's density, which is affected by the density of the solution or the amount of soluble particles present. The outcomes were noted and represented as %Brix (7).

2.2.5 Ash percentage analysis

Ash content indicates the minerals in the food sample, which is crucial for numerous biochemical reactions that support the body's primary metabolic processes [8]. In this study, a muffle furnace was employed to determine the ash percentage in banana jam. The process involved taking a specific amount of the sample, placing it in a dried porcelain crucible, and burning it at 500°C. After cooling them in a desiccator, the crucible was weighed, and the remaining inorganic substances underwent analysis. The ash test results were expressed as a percentage of ash, calculated by dividing the weight of the ash by the weight of the original sample and multiplying by 100 (9).

2.2.6 pH analysis

pH meter with standard buffer solutions of 4.0 and 7.0 were calibrated. To measure the product's level of acidity or alkalinity, the electrodes were placed directly into a 10-milliliter beaker containing the banana jam sample. Prior to proceeding on to the next sample, the pH meter was thoroughly rinsed with distilled water after use [8].

2.2.7 Moisture Content analysis

Considering the material's layers might have varying moisture contents, a well-mixed 1g sample of banana jam was used. On the moisture analyzer pan, the sample was equally distributed (1 to 3 mm thick) to guarantee even heat distribution and efficient drying without leaving any damp spots (10). The moisture content was recorded after the process completed with a beep sound.

2.2.8 Viscosity analysis

A rheometer with a matching cone-and-plate was used to analyse the viscosity of banana jam. Due to the temperature-dependent nature of viscosity, temperature control may be required. Temperature of rheometer was set to 25 ^{o}C throughout the reading process. A small amount of banana jam was spread on the stage of rheometer. The data obtained from the reading was recorded and analysed.

2.2.9 Texture analysis

Texture profile analysis was conducted using Texture Analyser (TA.XTplusC Stable Micro System Ltd). The texture properties that were evaluated and observed are hardness, and stickiness. The data analysed for a better understanding of the textural characteristics of the banana jam.

2.3 Statistical Analysis

Results were subjected to statistical analysis using a t-test by Microsoft Excel. The values that were reported as mean ± standard deviation were chosen to determine any significant difference among the samples. T-test is a statistical technique for comparing two groups' means and determining whether there is a significant difference in their means (11). It defines if the observed variations in the group means may be explained by chance or if they are statistically significant. If the *p*-value is less than the significance level (0.05), the null hypothesis will be rejected, suggesting that there is a significant difference between the groups. Meanwhile, if the *p*-value is greater than the significance level, the null hypothesis fails to be rejected, indicating that there is not enough evidence to claim a significant difference (12).

3. Results and Discussion

3.1 Sensory Evaluation

Banana jam with *Musa acuminata* variety was chosen from the sensory evaluation done by 60 panellists. This part of study discusses the results of sensory evaluation using affective test. Based on the Table 1, the mean colour score of *M. acuminata* (5.45) was greater than that of *M. paradisiaca* (4.93). The panellists' varying perspectives on colour are depicted by the standard deviations. *M. acuminata* has slightly lower mean scores (4.73) for aroma than *M. paradisiaca* (4.88). The standard deviations point to a moderate level of variation in how panellists perceive aromas. *M. acuminata* received a slightly higher average rating (5.4) for flavour compared to *M. paradisiaca* (5.23). For texture, aftertaste and overall acceptance, *M. acuminata* have a slightly higher mean value compared to *M. paradisiaca*, with the mean of 5.5 for texture, 5.43 for aftertaste, and 5.58 for overall acceptance, over 5.36, 5.13, and 5.53, respectively. Although there are some variations in the mean values, they are typically minor, suggesting that both varieties of bananas are very well-liked for the evaluated sensory aspects. To summarise, the overall acceptance provides an insight that *M. acuminata* sample has higher preferences than *M. paradisiaca* sample. From the t-test displayed in Table 2, it can be concluded that there is no significant difference between the overall acceptability of *M. acuminata* jam and *M. paradisiaca* jam ($p > 0.05$).

Table 1 *Means Value of Sensory Attributes*

Types of Banana	Sensory Attributes					
	Colour	Aroma	Flavour	Texture	Aftertaste	Overall acceptance
Musa acuminata	5.45 ± 1.39	4.73 ± 1.58	5.4 ± 1.34	5.5 ± 1.45	5.43 ± 1.47	5.58 ± 1.26
Musa paradisiaca	4.93 ± 1.52	4.88 ± 1.58	5.23 ± 1.58	5.36 ± 1.62	5.13 ± 1.67	5.53 ± 1.52

Table 2 *t-Test Paired Two Sample for Means*

t-Test: Paired Two Sample for Means

	Musa acuminata	*Musa paradisiaca*
Mean	5.583333333	5.533333333
Variance	1.603107345	2.320903955
Observations	60	60
Pearson Correlation	0.556506765	
Hypothesized Mean Difference	0	
df	59	
t Stat	0.290527614	
P(T<=t) one-tail	0.386215701	
t Critical one-tail	1.671093032	
P(T<=t) two-tail	0.772431403	
t Critical two-tail	2.000995378	

3.2 Colour Analysis

Based on the result observed in Table 3, the L* value for *M. acuminata* (0.51) is much lower than the L* value of *M. paradisiaca* (28.05). Where L* = 0 corresponds to absolute black or in other words no colour, while L* = 100 corresponds to absolute white or with maximum light [13]. This shows that *M. acuminata* has a darker colour compared to *M. paradisiaca*. a* is green to red component, where *M. acuminata* has a* value of 2.84, suggesting a mild reddish tint, while *M. paradisiaca* has a* value of 5.96, indicating a more noticeable reddish tint. For b* which indicates blue to yellow component, *M. acuminata* has a b* value of 0.88, suggesting a moderate yellowish tint. Whereas *M. paradisiaca* has a b* value of 33.7, indicating a strong yellowish tint.

The t-test results in Table 4 reveal a highly significant difference in brightness (L* values) between *M. acuminata* and *M. paradisiaca*, as evidenced by the *p*-value lower than 0.05 ($p < 0.05$). The positive Pearson correlation (0.581) indicates a moderate positive relationship between the L* values of the two banana varieties. These findings suggest a substantial contrast in brightness between *M. acuminata* and *M. paradisiaca*, with statistical significance. Based on Table 5 which is a t-test conducted for a* values, it shows that $p < 0.05$. With *p*-value well below common significance thresholds, it can be summarised that the observed contrast in 'a' value is statistically significant. The paired t-test results for the b* value between *M. acuminata* and *M. paradisiaca* displayed in Table 6 indicate an extremely low *p*-value ($p < 0.05$). Thus, there is also a significant difference in the b* value between the two banana varieties. These findings offer compelling evidence that the two banana varieties differ significantly in terms of all colour parameters.

Table 3 *Means Value of L*, a*, and b* of Both Types of Banana*

Types of Banana	Colour of Sample		
	L*	**a***	**b***
Musa acuminata	0.51 ± 0.07	2.84 ± 0.31	0.88 ± 0.12
Musa paradisiaca	28.05 ± 0.98	5.96 ± 0.04	33.7 ± 1.09

Table 4 *t-Test: Paired Two Sample for Means (L* Value)*

t-Test: Paired Two Sample for Means

	M. acuminata	*M. paradisiaca*
Mean	0.516667	28.05667
Variance	0.004933	0.970433
Observations	3	3
Pearson Correlation	0.581478	
Hypothesized Mean Difference	0	
df	2	
t Stat	-50.424	
P(T<=t) one-tail	0.000197	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.000393	
t Critical two-tail	4.302653	

Table 5 *t-Test: Paired Two Sample for Means (a* Value)*

t-Test: Paired Two Sample for Means

	M. acuminata	*M. paradisiaca*
Mean	2.846667	5.96
Variance	0.097733	0.0019
Observations	3	3
Pearson Correlation	-0.87327	
Hypothesized Mean Difference	0	
df	2	
t Stat	-15.3486	

P(T<=t) one-tail	0.002109
t Critical one-tail	2.919986
P(T<=t) two-tail	0.004218
t Critical two-tail	4.302653

Table 6 *t-Test: Paired Two Sample for Means (b* Value*)

t-Test: Paired Two Sample for Means

	M. acuminata	*M. paradisiaca*
Mean	0.886667	33.7
Variance	0.015833	1.1932
Observations	3	3
Pearson Correlation	-0.9749	
Hypothesized Mean Difference	0	
df	2	
t Stat	-46.7644	
P(T<=t) one-tail	0.000228	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.000457	
t Critical two-tail	4.302653	

3.3 Total Soluble Solids Analysis

Total Soluble Solids (TSS) of *M. acuminata* with a mean value of 61.91 while *M. paradisiaca* had a slightly higher mean value of 65.29 were listed in Table 7. This suggests that *M. paradisiaca* has a higher sugar content or sweetness than *M. acuminata.* The results of this study were similar to the previous study that state that jam was cooked with sugar with addition of pectin until enough water has evaporated should have a total soluble solid of more than 65 % [14]. According to Sawant and Patil (2013), an increase in total soluble solids resulted from the breakdown of pectin and the enzymatic conversion of monosaccharides into sugar molecules [15]. From the t-test shown in the Table 8, the high positive correlation (0.96) suggests that the two variables are closely related. The negative t-Stat suggests that *M. paradisiaca* has a significantly higher mean than *M. acuminata*. In summary, the paired two-sample t-test indicates a statistically significant difference in means between *M. acuminata* and *M. paradisiaca*, with *M. paradisiaca* having a higher mean.

Table 7 *Means Value of Total Soluble Solids*

Types of Banana	**Brix of Sample**
Musa acuminata	61.91 ± 0.71
Musa paradisiaca	65.29 ± 0.62

Table 8 *t-Test: Paired Two Sample for Means*

t-Test: Paired Two Sample for Means (TSS)

	Musa acuminata	*Musa paradisiaca*
Mean	61.91	65.29667
Variance	0.5061	0.386233
Observations	3	3
Pearson Correlation	0.961384	
Hypothesized Mean Difference	0	
df	2	
t Stat	-28.5434	
P(T<=t) one-tail	0.000613	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.001225	
t Critical two-tail	4.302653	

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3.4 Ash Percentage Analysis

The ash content of *M. acuminata* sample is 2.31% while the ash content of *M. paradisiaca* sample is 1.06%. This demonstrates that *M. acuminata* has a higher ash percentage compared to *M. paradisiaca*. Variations in ash content can be caused by changes in the mineral content in each of banana type. The mineral composition of the soil that bananas are grown in affects how much ash they contain. The results obtained from this study were not similar to a study done by Olugbenga *et al*. (2018), which shows that the ash content of the composite sample ranged from 0.27 to 0.38 % [8]. This data is slightly lower than the percentage of ash obtained in this study which ranges between 1.06 to 2.31%. This is because the previous study used jam from the blends of banana, pineapple and watermelon. The differential in components of the jams can give alteration to the value of mineral composition in a particular sample. Thus, affecting the percentage of ash present in each of the samples.

3.5 pH Analysis

The pH mean for *M. acuminata* is 4.11 while the pH mean for *M. paradisiaca* is 3.89 as presented in Table 9. This shows that pH of *M. paradisiaca* is slightly lower than that of *M. acuminata* which suggests that *M. acuminata* has lower acidity compared to *M. paradisiaca.* This may be due to different species used within Musa genus, which are *M. acuminata* and *M. paradisiaca* which may naturally have different acidity levels. From the previous study in 2018, the search results indicate that the pH of banana jam usually ranges from 3.55 to 4.70, depending on several factors including the quantity of banana pulp used and the presence of citric acid [8]. Since the result of pH value obtained from this study is between the range of 3.8 to 4.2, which is in the common pH range, so there is a strong support that the banana jams made are in the right formulation to be taken into wider commercialization. Considering the non-overlapping ranges of mean ± standard deviation, the pH values of *M. acuminata* and *M. paradisiaca* appear to differ significantly due to the *p*-value that is less than 0.05, as presented in Table 10. *M. paradisiaca*'s lowered standard deviation suggests a more stable pH level. Both types of bananas show relatively low standard deviation, which indicates the precision and consistency of pH value for each type of banana.

Table 9 *Mean Value of pH*

Types of Banana	pH Value
Musa acuminata	4.11 ± 0.04
Musa paradisiaca	3.89 ± 0.01

Table 10 *t-Test: Paired Two Sample for Means*

	Musa acuminata	*Musa paradisiaca*
Mean	4.106667	3.89
Variance	0.001233	0.0001
Observations	3	3
Pearson Correlation	0.996616	
Hypothesized Mean Difference	0	
df	2	
t Stat	14.91202	
P(T<=t) one-tail	0.002233	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.004467	
t Critical two-tail	4.302653	

3.6 Moisture Content Analysis

The moisture content mean value stated in Table 11 for *M. acuminata* is 33.8 while the moisture content mean value for *M. paradisiaca* is 27.95. The difference between the means indicates that *M. acuminata* has higher moisture if compared to that of *M. paradisiaca*. The paired character of the t-test is supported by the very high positive correlation (0.996), which indicates a strong relationship between the two variables. Since the *p*-value presented in Table 12 is less than 0.05 ($p < 0.05$), it can be summarized that there is a significant difference between *M. acuminata* and *M. paradisiaca*, with *M. acuminata* having a higher mean.

Table 11 *Mean Value of Moisture Content*

Types of Bananas	Mean Moisture Content
Musa acuminata	33.8 ± 1.83
Musa paradisiaca	27.95 ± 1.10

Table 12 *t-Test: Paired Two Sample for Means*

	Musa acuminata	*Musa paradisiaca*
Mean	33.8	27.95333
Variance	3.3327	1.215433
Observations	3	3
Pearson Correlation	0.995936	
Hypothesized Mean Difference	0	
df	2	
t Stat	13.79052	
P(T<=t) one-tail	0.002609	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.005217	
t Critical two-tail	4.302653	

3.7 Viscosity Analysis

Different types of fruit jams produce different viscosity. Viscosity decreases as temperature increases. Banana jam is categorised as non-Newtonian fluid since it contains gels which use pectin as thickening agent. Considering there is no direct correlation between shear rate and shear stress in non-Newtonian fluids, shear stress will either rise or fall as the shear rate rises. From the data obtained, the viscosity tends to decrease with increasing shear rate. This shear rate increase can be shown in Table 13 of *M. acuminata* sample, at row 2, viscosity is 81.37 Pa.s at a shear rate of 2.15 1/s, while at row 3, viscosity decreases to 32.63 Pa.s at a higher shear rate of 4.64 1/s. Table 14 shows the shear rate and viscosity of *M. paradisiaca*. At row 2, viscosity is 58.78 Pa.s at a shear rate of 2.15 1/s, while at row 3, viscosity decreases to 25.08 Pa.s at a higher shear rate of 4.64 1/s. Both samples were observed at the temperature remains relatively constant at around 25 ^{o}C. This was similar to the earlier study that scientists had conducted [16].

Table 13 *Shear Rate and Viscosity of Musa acuminata sample*

Reading	Shear Rate (1/s)	Viscosity (Pa.s)
1	1.00114	185.768
2	2.15690	81.3757
3	4.64677	32.6318

Table 14 *Shear Rate and Viscosity of Musa paradisiaca sample*

Reading	Shear Rate (1/s)	Viscosity (Pa.s)
1	1.00001	129.730
2	2.15449	58.7873
3	4.64151	25.0817

3.8 Texture Analysis

In contrast to *M. paradisiaca* (59.19), *M. acuminata* has a greater hardness value (66.32) as provided in Table 15. In general, this implies that *M. acuminata* is more solid or harder than *M. paradisiaca*. *M. acuminata* exhibits a stickiness value of −47.49, which is lower than that of *M. paradisiaca* (− 44.34). *M. acuminata* appears less sticky than *M. paradisiaca*. Different values of hardness might be affected by the type of banana used. The banana that was used was fairly ripe and may have had a high pectin content. According to [17], the expense of protopectin caused the pectin content to rise significantly throughout the ripening process that might affect the texture of banana jams.

Table 15 *Mean Value of Hardness and Stickiness of Musa acuminata and Musa paradisiaca*

Types of Banana	Hardness	Stickiness
Musa acuminata	66.32 ± 2.36	-47.49 ± 1.57
Musa paradisiaca	59.19 ± 3.22	-44.34 ± 3.91

4. Conclusion

In conclusion, the study highlights distinct differences between *M. acuminata* and *M. paradisiaca* in various physicochemical aspects including colour, total soluble solids, ash content, pH, moisture content, and viscosity. The formulation of both banana jams flavour had been effectively developed. *M. acuminata* has a darker colour than *M. paradisiaca*, as determined by colour analysis. The study of total soluble solids revealed that *M. paradisiaca* has more sugar (65.29) than *M. acuminata* (61.91). An examination of ash percentage revealed that *M. acuminata* had a larger percentage of ash (2.31%) than *M. paradisiaca* (1.06%), presumably as a result of differences in mineral composition. *M. acuminata* exhibits less acidity (4.11) than *M. paradisiaca* (3.89), based on the pH study that was successfully conducted. *M. acuminata* has a greater moisture content (33.8) than *M. paradisiaca* (27.95), corresponding to a moisture analysis. Viscosity studies discovered that both samples exhibited typical non-Newtonian fluid behaviour. In accordance with a texture analysis, *M. acuminata* was discovered to be less sticky and harder than *M. paradisiaca.* From the results of sensory evaluation, the overall acceptability of *M. acuminata* (5.58), which is slightly greater than that of *M. paradisiaca* (5.53), proves that consumers prefer *M. acuminata* over *M. paradisiaca*. These findings provide valuable insights into the compositional disparities between the two banana varieties, offering essential information for potential applications in the food industry. Further studies should be conducted to determine the nutritional compositions in different types of bananas and possible addition of ingredients to improve its nutritional content.

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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:*** *Nurul Amirah Mohamad Diah, Saliza Asman;* ***data collection:*** *Saliza Asman;* ***analysis and interpretation of results:*** *Nurul Amirah Mohamad Diah, Saliza Asman;* ***draft manuscript preparation:*** *Nurul Amirah Mohamad Diah, Saliza Asman. All authors reviewed the results and approved the final version of the manuscript.*

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