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Formulation of Guava Jelly Incorporated with *Moringa Oleifera* Leaves Extract as Functional Food

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Abstract

This study explores the development of a functional food product by incorporating *Moringa oleifera* leaf extract into guava jelly, aiming to enhance its nutritional profile while maintaining desirable physicochemical and sensory properties. Three formulations with increasing concentrations of moringa extract (25%, 35%, and 45%) were prepared alongside a control. Physicochemical analyses revealed significant changes with increasing moringa incorporation: moisture content decreased from 34.66% in control to 29.95% in the highest formulation, while pH varied slightly, maintaining the ideal range for jelly stability. Total soluble solids (TSS) values remained stable across all formulations, averaging 66 °Brix, ensuring sweetness and shelf-life consistency. Texture Profile Analysis (TPA) showed no significant differences in firmness across samples, with values ranging from 5.21 N to 5.59 N. However, the work of shear decreased significantly in higher formulations, indicating a reduction in cohesiveness, with values dropping from 324.80 g·sec in the control to 218.40 g·sec in the highest formulation. Nutritional composition analyses highlighted significant improvements in protein content, with the highest formulation containing 2.02% compared to 1.07% in the control. Carbohydrate levels also increased, peaking at 71.66%, while ash content rose slightly, reflecting the mineral contribution of *M. oleifera*. A sensory evaluation conducted using a 9-point hedonic scale indicated that while the control was most preferred, formulations with incorporations of moderate *M. oleifera* leaf extract (F2 with 35%) still retained acceptable taste, texture, and overall appeal. The findings suggest that incorporating *M. oleifera* leaf extract into guava jelly enhances its nutritional value, particularly in protein and mineral content, while maintaining consumer acceptability. This innovation contributes to advancing functional food development while addressing dietary gaps in nutrient intake.

1. Introduction

Jelly stands out as a highly digestible and appealing food option, offering superior nutrition compared to many synthetic beverages and some confectionery items commonly consumed daily. It is a translucent product with a semi-solid texture, created by blending strained fruit juice or aqueous extracts from one or more fruits with sweetening agents, sometimes with added water [1]. Incorporating fruits and vegetables into jelly is significant

due to its nutritional value and potential health benefits, making it a worthwhile component of a balanced diet. Common fruits used in jelly-making include guava, grape, strawberry, apple, mango, and pineapple [2].

Guava (P*sidium guajava L.*), a tropical fruit widely recognized for its unique flavour and rich in nutritional content, and antioxidant properties, serves as an excellent base for functional food development [3]. Guava fruit is chosen for making jelly instead of other fruits due to its naturally rich in pectin and possesses a unique flavour profile that sets it apart from other fruit which is essential for jelly-making [4]. Its tropical, sweet-tart taste adds a delightful twist to jellies, appealing to consumers seeking diverse and exotic fruit flavours. Guava is packed with essential nutrients rich in vitamins such as vitamins C, A, E, and K. It also contains minerals like potassium, magnesium, calcium, and phosphorus which is suitable for the development of snack products [5][6]. In this jelly development, a small amount of pectin was added, despite guava being naturally rich in pectin, to reduce cooking time. This helps preserve the guava's fresh flavour and vibrant colour, as longer boiling can cause flavour loss and colour dulling [7]. Consuming guava jelly made from real guava fruit can contribute to meeting daily vitamin and mineral requirements, but it may lack certain essential nutrients, antioxidants, and bioactive compounds. This is where functional foods come into play, it can be achieved by incorporating the moringa leaves into guava jelly.

Moringa oleifera, commonly known as the drumstick tree in Asian communities, was acknowledged as a functional food with medicinal properties. The moringa tree offered numerous nutritional and medicinal advantages. It is hailed as a miraculous plant, showcasing exceptional dietary, therapeutic, and antioxidant attributes [8]. Moringa leaves rich in macronutrients, micronutrients, and other bioactive compounds crucial for maintaining optimal human body function [9]. Incorporating *Moringa oleifera* leaf extracts can enhance the nutritional profile by adding vitamins, minerals, protein, antioxidants, and phytochemicals present in moringa leaves [10], it is possible to create a novel functional food that combines the health-promoting properties of both ingredients.

This study aims to develop the formulation of guava jelly incorporated with *M. oleifera* leaf extract to improve its nutritional profile. Considering the increasing demand for functional foods, enhancing the nutritional content, functional benefits, and sensory experience of guava jellies can make them more appealing and beneficial to consumers. This study provides valuable information on the formulation, physicochemical properties, nutritional composition, and sensory acceptance of guava jelly enriched with *M. oleifera* leaves extract, exploring its potential as a functional food product.

2. Methodology

2.1 Materials

The guava fruit, lemon, and sugar were purchased at a local supermarket in Pekan Pagoh, Muar, Johor area. The incorporating ingredient in jellies consists of *Moringa oleifera* leaves, which were harvested directly from the plant at Kg. Jelor, Pasir Puteh, Kelantan. Meanwhile, pectin was purchased at a local supermarket in Pasir Puteh, Kelantan. The guava jellies were prepared by following the method with slight modifications by [11][12] and [13].

2.2 Sample Preparation and Formulation

1000g of guava (*Psidium guajava*) fruits were washed to remove dirt and pilled the skin. Guava fruits were cut into small pieces before being blended and filtered to yield guava juice. The juice then was refrigerated at 4°C before jelly preparation [14][11]. The fresh *M. oleifera* leaves were harvested directly from the plant and the leaves were detached from their branches, washed with tap water to eliminate dirt, and air-dried in a shaded area to prevent vitamin loss due to direct sunlight exposure. The dried *M. oleifera* leaves were ground into a powder and passed through a sieve to ensure consistent particle size. Next, 50g of leaf powder was soaked in 500 mL of hot water (previously boiled) for 30 minutes, followed by the resulting extract being strained using a muslin cloth. The clarified juice extract was then kept in a refrigerator at 4°C before usage for jelly preparation [11].

Table 1 Formulation of guava jelly

Materials	Formulation (%)			
	Control	1	2	3
Guava juice	100	75	65	55
Moringa leaf extract	0	25	35	45
Sugar	35	35	35	35
Pectin	5	5	5	5
Lemon juice	10	10	10	10

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For the jelly preparation, all the ingredients were weighed according to the formulation ratio in Table 1. The mixture of guava juice, moringa leaf extract, and sugar was heated and stirred at the same time until the temperature reached 80℃. Subsequently, 5% of pectin and 10% of lemon juice were added into each formulation, and the mixtures were boiled in a cooking pan at 90℃, with continuous stirring to prevent coagulation and sticking. The mixture was allowed to boil until it reached a gel-like consistency. Then, the jelly was poured into jars, cooled at room temperature, and refrigerated at 10℃ before ready for further analysis [11][13].

3. Methods

3.1 Determination of Moisture Content

Moisture content was analysed in triplicate by using the moisture analyser MX-50 (A&D, Japan) according to the category sample cold beverage (jellylike), and the program's mode was set based on the category sample (1 gram sample at 140℃). About 1 gram of each sample was placed into a moisture analyser and run for 17 minutes.

3.1.1 Determination of pH

The pH value of the samples was taken in triplicate using a pH meter (Sanxin SX751, China). The method used adhered to the guidelines outlined in the Association of Official Analytical Chemists (AOAC). About 10 grams of the sample was dissolved in 75 mL of distilled water, and the solution was homogenized using a sonicator for 30 minutes before pH meter readings were taken [15].

3.1.2 Determination of Total Soluble Solids (TSS)

The total soluble solids content was assessed with a refractometer. Two drops from each sample were dispensed using a dropper on the prism plate of the refractometer (Atago Digital Refractometer RX-9000a) and the measurements were performed in triplicate. The results were then recorded as soluble solids contents in °Brix [15].

3.1.3 Determination of Texture Analysis

The texture profile of jellies was assessed using the Texture Analyzer (TA-XT2, Stable Micro System, Haslemere, UK) to determine the firmness and work of shear. The parameter of the jelly's texture was measured by connecting a cylindrical probe (HPD/SR, Spreadability Rig) with specific settings: pre-test speed of 1.00 mm/s, test speed of 3.00 mm/s, post-test speed of 10.00 mm/s, and a load cell of 5 g. The texture profile analysis of jellies was conducted for three (3) replications each. The analysed results were retrieved from the Texture Pro CT Software installed in their respective units [16].

3.1.4 Determination of Protein Content

The protein content of jellies was analysed using the Kjeldahl method following AOAC (2000). About 10 grams of the sample was dried overnight at 105°C in a Kjeldahl flask. The dried sample then undergoes hydrolysis with concentrated sulfuric acid (H_2SO_4) at a ratio of 1:10 to the total weight of the residue. Additionally, 1 gram of copper (II) sulphate anhydrous ($CuSO_4$) will be added to the mixture, which will be heated for 2 to 3 hours at around 420°C. After cooling, distilled water was added to the samples before proceeding with the neutralization and titration procedure. The protein content of the jellies can be determined using equation 1 [12].

$$\textbf{Protein}\ (\%) = \frac{\textbf{V NaOH (blank} - \textbf{sample)} \times \textbf{N NaOH} \times \textbf{14.007} \times \textbf{6.25} \times \textbf{100}}{\textbf{sample weight (g)} \times \textbf{1000}} \quad (1)$$

3.1.5 Determination of Fat Content

The fat content was verified using the AOAC-described solvent extraction gravimetric technique (2000). Approximately five (5) grams of the sample was enclosed in porous paper and placed inside a thimble (Whatman filter paper). This thimble, along with a weighed extraction flask containing 200 ml of petroleum ether, was mounted in a Soxhlet reflux flask for extraction. After being heated, the petroleum ether boiled and condensed into the reflux flask. The oil extract was then moved into the boiling flask. The defatted sample is then removed, the solvent recovered, and the oil extract retained in the flask. To eliminate any residual solvent, the flask holding the oil extract undergoes drying in an oven at 60°C for one minute. Following cooling in a desiccator, it was weighed. The fat content was assessed by following equation 2 [12].

$$\textbf{Fat}\ (\%) = \frac{\textbf{petri dish weight with sample (g)} - \textbf{weight of petri dish without sample (g)}}{\textbf{weight of the sample (g)}} \times \textbf{100} \quad (2)$$

3.1.6 Determination of Ash Content

The ash content of jellies was performed according to the AOAC method (2000). The sample was first allowed to dry completely to determine the ash content of the high-moisture product. In brief, the crucible and its lid were heated in the furnace at 550°C until all impurities on the crucible's surface were burned off. Subsequently, they were cooled in a desiccator for 30 minutes before being weighed. Following this, five (5) grams of the sample were placed into the crucible and subjected to incineration in a muffle furnace set to 550°C until completely reduced to ash. The equation (3) was used to calculate the ash content [12].

$$\textbf{Ash content}\ (\%) = \frac{\textbf{wt of the crucible with ash residue (g)} - \textbf{wt of empty crucible (g)}}{\textbf{sample wt (g)}} \times \mathbf{100} \quad (3)$$

3.1.7 Determination of Carbohydrate Content

Carbohydrates were calculated following the method of AOAC (2000), and the formula as in equation (4) was used [12].

$$\text{Carbohydrate (\%)} = 100 - [\text{Protein (\%)} + \text{Fat (\%)} + \text{Ash (\%)} + \text{Moisture (\%)}] \quad (4)$$

3.1.8 Determination of Sensory Evaluation

Acceptance test using 9-Hedonic Scale were used to conduct the sensory analysis and about 50 untrained panellists from UTHM Pagoh's were selected. Four types of samples including control were prepared during the sensory assessment. The samples were cut into small pieces approximately 1 cm x 1 cm in size. The samples that were coded with a 3-digit random number were served on white plates. Each panellist was supplied with a glass of water for oral rinsing between each sample to clear his or her palate. The panellists will assess their preferences for the appearance, colour, aroma, texture, taste, aftertaste, and overall acceptability of guava jelly using a 9-point hedonic scale, which ranges from 1 'dislike extremely' to 9 'like extremely' [17].

3.1.9 Statistical Analysis

Every parameter for physicochemical properties, proximate composition, and sensory evaluation analysis was analysed in triplicate, with the results expressed as the mean ± standard deviation (SD). To identify statistically significant differences among the four formulations including the control, an analysis of variance (ANOVA) was performed using Minitab software. A *p*-value of ≤ 0.05 will be considered significant, indicating statistical significance when the *p*-value is 0.05 or below. Post hoc analysis used Tukey's test to determine specific group differences.

4. Results and Discussion

4.1 Physicochemical Properties

The moisture content, pH, and total soluble solids of all guava jelly samples were analysed by using the method as explained in the methodology section. The obtained result for all samples of guava jelly was calculated and tabulated in Table 2.

Table 2 Moisture content, pH value, TSS of guava jelly

Sample	Moisture content (%)	pH value	TSS (°Brix)
Control	34.66±0.11^{a}	3.29±0.04^{ab}	64.93±3.74^{a}
F1	32.95±0.37^{b}	3.19±0.03^{b}	67.32±0.29^{a}
F2	31.87±0.57^{b}	3.21±0.06^{b}	66.77±0.62^{a}
F3	29.95±0.47^{c}	3.38±0.02^{a}	66.55±1.34^{a}

^{abc} Means with different letters within a column differ significantly ($p \leq 0.05$)

4.1.1 Moisture Content Analysis

The result of the moisture content in Table 2 shows that it decreased significantly with higher concentrations of Moringa oleifera leaf extract. The control sample showed the highest moisture content at 34.66%, while the F3 sample, containing the highest level of extract, exhibited the lowest at 29.95%. This reduction is likely due to the hygroscopic nature of Moringa leaves and alterations in the gel matrix, contributing to enhanced shelf stability through lower water activity but requiring balance to maintain texture [18].

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The significant differences in moisture content among the samples explain how *M. oleifera* leaf extract impacts the physicochemical properties of guava jelly, potentially enhancing shelf stability by reducing water activity, which can inhibit microbial growth [12]. However, it is also crucial to balance moisture content to maintain the desired jelly texture and avoid excessive firmness, as lower moisture levels could compromise consumer acceptability.

4.1.2 pH Analysis

The pH of guava jelly samples varied significantly. The control had a pH of 3.29, while F3 showed a higher pH of 3.38. Samples F1 and F2 exhibited slightly lower pH values 3.19 and 3.21, respectively. These differences are attributed to the alkaline components of the extract and its interaction with guava's acidic components [19]. The significant differences in pH values are critical in understanding the formulation's impact on product quality and stability. Proper pH control is essential for gelation, microbial stability, and sensory attributes [20]. For instance, maintaining a slightly acidic pH is essential for proper jelly gelation and to ensure a pleasant taste profile.

4.1.3 Total Soluble Solids (TSS) Analysis

The total soluble solids (TSS) values, expressed in °Brix, showed minor and statistically insignificant differences. The control measured 64.93 °Brix, while F1, F2, and F3 recorded slightly higher values of 67.32, 66.77, and 66.55 °Brix, respectively. The stability in TSS indicates that *M. oleifera* leaf extract does not significantly affect soluble solid concentrations, ensuring the jelly's sweetness, texture, and stability remain intact. However, the minor variations are likely because the formulations were also varied in guava juice level and had a slight addition of pectin, sugar, and lemon juice despite the addition of the leaf extract, leading to a slight increase in TSS [21].

4.2 Texture Profile Analysis (TPA)

The Texture Profile Analysis (TPA) results of guava jelly samples, as presented in Table 3, reveal the firmness and work of shear properties, which are critical indicators of the jelly's texture.

Table 3 Texture profile of guava jelly

Sample	Firmness (N)	Work of shear (g.sec)
Control	5.21±0.61^{a}	324.80±16.26^{a}
F1	5.59 ±0.15^{a}	298.59±16.08^{a}
F2	5.48±0.27^{a}	234.30±29.40^{b}
F3	5.37±0.19^{a}	218.40±19.90^{b}

^{abc}Means with different letters within a column differ significantly ($p \leq 0.05$)

Firmness values ranged from 5.21 N in the control sample to 5.59 N in F1, and then the firmness decreased for F2 (5.48 N) and F3 (5.37 N). While these differences suggest a slight trend toward increased firmness with the incorporation of *M. oleifera* leaf extract, the variations are not statistically significant, as indicated by identical superscripts for firmness across all samples. The decrease in firmness from F1 to F3 also may be affected by sugar and pectin concentrations that come naturally from guava fruit. As the previous study mentioned the addition of both sugar and pectin influenced the textural properties of the prepared jellies [22].

Conversely, the work of shear values showed significant differences among the samples. The control sample exhibited the highest work of shear 324.80 g·sec, reflecting its cohesiveness and resistance to breaking under stress [23]. In comparison, F2 and F3 displayed significantly lower work of shear values, 234.30 g·sec and 218.40 g·sec, respectively, indicating a reduction in cohesiveness with higher levels of *Moringa oleifera* leaf extract. This trend suggests that while the addition of the leaf extract does not drastically alter firmness, it affects the gel matrix's internal structure, reducing its ability to resist deformation during shearing. These findings emphasize the importance of optimizing the *Moringa oleifera* leaf extract concentration to balance its nutritional benefits with desirable textural attributes, ensuring the jelly remains both functional and appealing.

4.3 Proximate Composition

The proximate analysis of guava jelly samples, shown in Table 4, highlights the nutritional composition, such as protein, fat, ash, and carbohydrate content, with statistically significant differences observed among the samples.

Table 4 Proximate composition of guava jelly

Sample	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Control	1.07±0.01^{b}	0.11±0.02^{b}	0.28±0.05^{a}	66.80±0.17^{c}
F1	1.02±0.00^{c}	0.23±0.05^{a}	0.26±0.05^{a}	68.57±0.43^{b}

F2	2.02±0.01[a]	0.18±0.05[ab]	0.32±0.01[a]	70.65±0.60[a]
F3	1.04±0.01[bc]	0.20±0.01[ab]	0.37±0.02[a]	71.66±0.49[a]

[abc]Means with different letters within a column differ significantly ($p \leq 0.05$)

4.3.1 Protein Analysis

Protein levels varied significantly across the formulations, with F2 showing the highest protein content 2.02%, significantly higher than the control (1.07%) and other formulations (F1 at 1.02% and F3 at 1.04%). The increase in protein is attributed to the incorporation of *Moringa oleifera* leaf extract, which known for its high protein content. This is supported by studies of Zungu et al. that shows the same outcome where the protein is increased when *Moringa oleifera* leaf powder has been added [24]. The significant variation in protein levels underscores the potential of *Moringa oleifera* to enhance the nutritional value of guava jelly, making it a functional food option.

4.3.2 Fat Analysis

Fat content showed slight variations, with F1 exhibiting the highest level 0.23% and the control having the lowest 0.11%. However, the differences between samples were not consistently significant, as indicated by overlapping superscripts for certain samples. The slight increase in fat levels can be attributed to the natural lipid content of *Moringa oleifera*, but the overall low-fat content of the jellies aligns with consumer demand for low-fat snacks. The previous studies by Chhikara et al. also shows the same outcome where there is a slight increase in fat levels when *Moringa oleifera* was incorporated [25].

4.3.3 Ash Analysis

Ash content, representing the mineral content, ranged from 0.26% to 0.37%, with no statistically significant differences between most samples. However, F3 had a slightly higher ash content 0.37%, which can be linked to the higher concentration of *Moringa oleifera*, rich in minerals such as calcium, potassium, and iron [25]. This trend reflects the potential of *Moringa oleifera* to fortify the jelly with essential micronutrients.

4.3.4 Carbohydrate Analysis

The carbohydrate content varied significantly among the samples, with F3 containing the highest carbohydrate level (71.66%), followed by F2 (70.65%), F1 (68.57%), and the control (66.80%). The significant increase in carbohydrate content with *Moringa oleifera* incorporation is due to the natural sugar in the moringa leaves extract, contributing to the total carbohydrate measurement. These findings suggest a potential increase in the caloric value of the jellies, which could be an important consideration for dietary planning.

The significant differences observed in protein and carbohydrate content, along with the trends in fat and ash content, underscore the potential of *Moringa oleifera* leaf extract as a functional ingredient for enhancing the nutritional profile of guava jelly. The increased protein content reflects the extract's capacity to fortify the jelly, making it a valuable source of plant-based protein for consumers seeking nutrient-dense foods. Similarly, the slight rise in ash content indicates the potential enrichment of essential minerals, contributing to the jelly's overall health benefits.

4.4 Sensory Evaluation

The sensory evaluation of guava jelly samples, as summarized in Table 5 reveals statistically significant differences across various sensory attributes. These differences reflect how the incorporation of *M. oleifera* leaf extract impacts the sensory characteristics of the jelly, which is crucial for consumer preference and product acceptance.

Table 5 Sensory evaluation of guava jelly

Sample	Sensory Attributes					
	Appearance	Texture	Aroma	Taste	Aftertaste	Overall Acceptability
Control	7.36±1.54[a]	6.30±1.75[a]	6.42±1.72[a]	6.82±1.68[a]	6.60±1.70[a]	6.74±1.58[a]
F1	7.08±1.61[ab]	5.52±1.96[a]	5.80±1.67[ab]	5.76±1.92[b]	5.84±1.70[ab]	6.14±1.55[ab]
F2	6.40±1.49[b]	6.28±1.88[a]	5.86±1.98[ab]	6.40±1.90[ab]	6.18±1.61[ab]	6.42±1.76[ab]
F3	5.42±1.45[c]	5.92±1.82[a]	5.42±1.65[b]	5.50±1.66[b]	5.62±1.53[b]	5.74±1.44[b]

[abc]Means with different letters within a column differ significantly ($p \leq 0.05$)

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The control sample received the highest scores in most attributes, emphasizing its preferred sensory profile. Meanwhile, samples with *Moringa oleifera* leaf extract (F1, F2, and F3) scored slightly lower in taste and aftertaste, potentially due to the distinct flavor of the leaf extract. However, among the three formulations incorporating *Moringa oleifera* leaf extract, F2 emerged as the most acceptable, as it scored relatively higher in several key sensory attributes compared to F1 and F3, despite falling slightly below the control with an overall acceptability score of 6.42. F3 exhibited the lowest overall acceptability score 5.74, suggesting a limit to the level of incorporation before sensory quality is compromised.

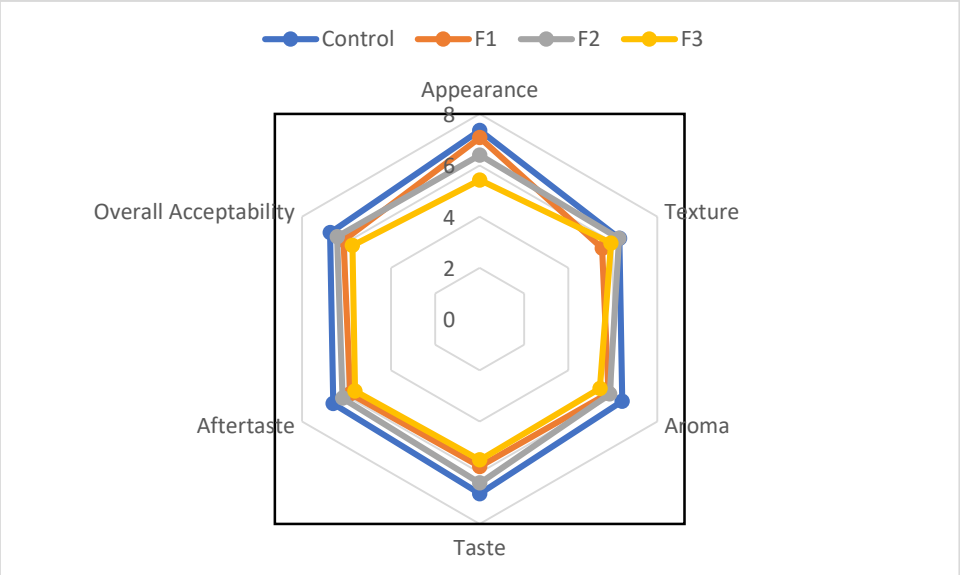

Fig 1 Sensory evaluation of guava jelly

4.4.1 Appearance Attributes

Appearance is a critical factor in consumer acceptance, as it influences initial impressions. The appearance scores varied significantly, with the control sample receiving the highest score 7.36 and F2 scored 6.40, slightly lower than F1 (7.08) but significantly higher than F3 (5.42). The decline in appearance scores with increasing levels of *Moringa oleifera* leaf extract may be attributed to visual changes such as darker coloration which could be less appealing to consumers familiar with the traditional translucent appearance of guava jelly.

4.4.2 Texture Attributes

The texture attribute did not show significant differences among the formulations, with F2 scoring 6.28, comparable to the control (6.30) and slightly higher than F3 (5.92). Although there were no statistically significant differences in texture scores among the samples, F2 showed a slight decline compared to the control, potentially due to the effect of the leaf extract on the gel matrix. This indicates that F2 retained a texture similar to traditional guava jelly, providing a familiar and pleasant mouthfeel, which contributed to its acceptability. While the texture remained generally acceptable, higher concentrations of *Moringa oleifera* might subtly alter the jelly's mouthfeel.

4.4.3 Aroma Attributes

Aroma scores demonstrated significant differences, with the control (6.42) outperforming F3 (5.42). The decline in aroma acceptability for samples containing *Moringa oleifera* could result from the distinct, earthy scent of the leaf extract, which may not align with consumer expectations for fruit-based jellies. However, among the three formulations containing *Moringa oleifera* leaf extract, aroma scores for F2 (5.86) were slightly better than F1 (5.80) and notably higher than F3 (5.42). This suggests that F2 managed to balance the distinct earthy aroma of *Moringa oleifera* with the fruity scent of guava jelly more effectively than F3, where the aroma might have been perceived as unpleasant. Previous studies indicate that excessive addition of *M. oleifera* leaf extract can result in a stronger unpleasant aroma and a spoiled odor in jelly [26].

4.4.4 Taste and Aftertaste Attributes

Taste and aftertaste scores also showed significant variations. The control sample had the highest scores for taste 6.82 and aftertaste 6.60, while F3 scored the lowest for both attributes 5.50 and 5.62, respectively. This trend indicates that the addition of *Moringa oleifera* leaf extract, particularly at higher concentrations, introduced flavours that might have been perceived as bitter or unfamiliar, affecting the jelly's palatability.

Taste is a crucial determinant of acceptability, as it directly affects consumer enjoyment. F2 scored 6.40, surpassing F1 (5.76) and F3 (5.50). The higher taste score for F2 indicates that the level of *Moringa oleifera* leaf extract in this formulation introduced minimal bitterness or off-flavours, allowing the sweet and fruity guava flavours to dominate, whereas F3's higher concentration of the extract may have resulted in stronger, less pleasant herbal notes.

Aftertaste results followed a similar trend, with F2 scoring 6.18, slightly higher than F1 (5.84) and significantly higher than F3 (5.62). This shows that F2 had a more favourable lingering flavour, without strong bitter or earthy notes often associated with *Moringa oleifera*. In F3, the aftertaste was likely less pleasant due to higher concentrations of the leaf extract.

4.4.5 Overall Attributes

The overall acceptability scores reflect the cumulative impact of the sensory attributes, with the control sample achieving the highest score 6.74 and F3 the lowest 5.74. F2 scored 6.42, slightly trailing the control (6.74) but higher than F1 (6.14) and F3 (5.74). This highlights F2 as the most balanced formulation, where the nutritional benefits of *Moringa oleifera* leaf extract were integrated without significantly compromising sensory appeal. The decline in overall acceptability suggests that while *Moringa oleifera* leaf extract enhances the jelly's nutritional value, it also introduces sensory characteristics that may not fully meet consumer expectations, especially at higher incorporation levels.

5. Conclusion

This study successfully addresses the critical need to develop an appealing and healthful guava jelly by investigating the effects of incorporating varying levels of Guava juice and *Moringa oleifera* leaf extract. The research objectives were achieved through a comprehensive analysis of guava jelly formulations on physicochemical properties, proximate composition, texture, and sensory attributes. The findings demonstrated that increasing the concentration of *Moringa oleifera* leaf extract significantly influenced moisture content, pH, and texture, as well as enhanced the nutritional profile, particularly protein and mineral content. Among the tested formulations, F2 emerged as the most balanced, offering a good compromise between enhanced nutritional value and acceptable sensory properties. While higher concentrations of *Moringa oleifera* (e.g., in F3) further improved nutritional content, they negatively impacted sensory attributes such as appearance, taste, and aftertaste, potentially reducing consumer acceptance. The moderate level of *Moringa oleifera* leaf extract provided nutritional benefits while minimizing undesirable changes to flavour and aroma, which were more pronounced in F3. Additionally, the appearance and texture of F2 remained close to consumer expectations for guava jelly, making it the most acceptable formulation overall among the three formulations excluded control sample.

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Conflict of Interest

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

6. Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nur Amirah Adnan, Hatijah Basri;* ***data collection:*** *Nur Amirah Adnan, Hatijah Basri;* ***analysis and interpretation of results:*** *Nur Amirah Adnan, Hatijah Basri;* ***draft manuscript preparation:*** *Nur Amirah Adnan, Hatijah Basri. All authors reviewed the results and approved the final version of the manuscript.*

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