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Sensory evaluation of papaya processed product formulations: child-friendly jelly candy

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Abstract. Fruit jelly candy is a popular confectionery product among children; however, the high use of sucrose is considered less suitable for children's health due to its potential to trigger obesity and dental caries. Therefore, a partial substitution of sucrose with liquid glucose is required, as liquid glucose offers several advantages, including lower sweetness intensity, a more moderate glycemic index, and the ability to produce a more elastic and stable texture. This study aimed to evaluate the sensory properties of papaya-based jelly candy formulated with varying combinations of sucrose and liquid glucose. Three formulations were tested, namely F1 (240 g sucrose : 360 g liquid glucose), F2 (300 g : 300 g), and F3 (360 g : 240 g). Sensory evaluation was conducted through a hedonic test by panelists assessing color, aroma, taste, and texture attributes. The results showed that formula F1 (240 g sucrose : 360 g liquid glucose) obtained the highest acceptance levels across nearly all parameters, particularly in taste and texture, which were most preferred by the panelists. Thus, F1 can be recommended as the optimal formulation for developing child-friendly papaya jelly candy with partial substitution of sucrose by liquid glucose.

1. Introduction

Papaya (*Carica papaya* L.) belongs to the tropical fruit group of the Caricaceae family and is widely favored by consumers across different social groups. The demand for ripe papaya is relatively high due to its sweet taste, distinctive aroma, and attractive flesh color, making it popular as a table fruit as well as a dessert. In addition, unripe papaya is also appreciated by consumers as a vegetable, a snack ingredient, or a component in traditional cakes. Empirical evidence suggests that regular consumption of ripe papaya may promote digestive health, alleviate eye-related disorders, and improve skin brightness [1]. The nutritional composition of ripe papaya per 100 g fresh weight is presented in table 1.

Table 1. Papaya, raw nutritional value per 100 g

Nutrient	Values
Calories	39
Carbohydrates	9.8 g
Fibers	1.8 g
Folates	38 µg
Vitamin A	1094 IU
Vitamin C	61.8 mg
Potassium	257 mg
Magnesium	10 mg
β-carotene	276 µg
β-kryptoxanthin	761 µg

Nevertheless, as a horticultural fruit product, papaya has certain drawbacks, particularly its soft and watery flesh texture, which is highly perishable and cannot be stored for long periods [2]. Various efforts to develop processed horticultural products have been increasingly carried out with the aim of extending shelf life, improving nutritional value, taste, color, texture, aroma, and aesthetic quality, as well as enhancing convenience and economic value [3]. Among such processed products, jelly candy is widely popular, especially among children.

Jelly candy is one of the most attractive fruit-based confectionery products for children due to its appealing color, taste, shape, and chewy texture. However, most jelly candies use sucrose as the primary sweetener in relatively high amounts. Excessive sucrose intake during childhood has been associated with several health risks, including dental caries, obesity, and increased risk of metabolic diseases. For example, a prospective study reported that high sucrose consumption from early childhood was correlated with increased dental caries scores by the age of 10 years [4]. Moreover, the American Heart Association has stated that excessive consumption of added sugars in children is associated with cardiovascular risk factors such as elevated triglyceride levels and reduced HDL cholesterol [5].

Therefore, alternative sweeteners with better health profiles are needed in the formulation of child-friendly processed products. Liquid glucose (glucose syrup) is one such candidate, offering several advantages over sucrose: its sweetness level can be more precisely controlled, it is more soluble, it contributes to a more elastic and soft jelly texture while reducing crystallization, and it may pose a lower metabolic burden compared to sucrose when used in moderate proportions (since sucrose consists of glucose and fructose, and excessive fructose intake is known to exert distinct metabolic effects).

Several studies have explored the substitution or combination of sucrose and glucose syrup in confectionery and jelly products, particularly regarding their effects on chemical and sensory properties. For instance, research on soybean milk candy demonstrated that varying sucrose-to-glucose syrup ratios significantly influenced taste, texture, and overall panelist acceptance [6]. Similarly, studies on jelly candy from seaweed (Eucheuma cottonii) found that adjustments in the sucrose–glucose composition affected sensory attributes such as taste and texture, with certain formulations being more favorably accepted [7].

Research on papaya-based processed products remains limited, particularly in the context of jelly candy suitable for children through partial substitution of sucrose with liquid glucose. Papaya itself is rich in vitamin A, vitamin C, dietary fiber, and antioxidants, making it a promising candidate as a functional food and local nutritional source [1]. This study, therefore, aimed to evaluate the sensory properties of papaya-based jelly candy formulated with different combinations of sucrose and liquid glucose. By substituting part of the sucrose with liquid glucose, it is expected that papaya jelly candy can become not only a healthier option but also a sensory-appealing confectionery product for children.

2. Materials and methods

2.1. Materials and equipment
The main raw material used in the production of papaya jelly candy was papaya filtrate (1000 g), obtained by filtering the blended flesh of ripe papaya. Sweetening agents included granulated sugar (240 g; 300 g; 360 g) as the source of sweetness and glucose syrup (360 g; 300 g; 240 g), which served to prevent sugar crystallization while enhancing the chewy texture. Gelling agents consisted of agar powder (14 g) and pectin (7 g), dissolved in hot water (150 ml) prior to incorporation. Citric acid (3 g), dissolved in 8 ml of room-temperature water, was added as an acidity regulator and flavor balancer, while cornstarch was used as a coating to prevent stickiness after the drying process.

The equipment employed included a stainless-steel saucepan for cooking, a gas stove as the heat source, and wooden or stainless-steel spatulas for stirring. Cooking temperature was controlled using a kitchen thermometer to ensure that the mixture reached the required temperature (105 °C). A candy mold was used for product shaping, while knives and cutting boards were applied for portioning. The drying process was carried out using a dehydrator at 55–60 °C. For the final stage, containers for cornstarch and powdered sugar were used, along with candy wraps, standing pouches for primary and secondary packaging, and a heat sealer for sealing. The finished products were labeled prior to marketing.

2.2. Experimental design
The experimental design applied in this study was a Randomized Complete Block Design (RCBD) with one factor, namely the sucrose–glucose syrup ratio, consisting of three treatments with three replications, resulting in nine samples in total. The treatments were as follows:

- P1: Sucrose (240 g), Glucose Syrup (360 g)
- P2: Sucrose (300 g), Glucose Syrup (300 g)
- P3: Sucrose (360 g), Glucose Syrup (240 g)

2.3. Preparation of papaya jelly candy
The preparation of papaya jelly candy began by mixing 1000 g of papaya filtrate with sucrose, glucose syrup, and 14 g of agar powder in a stainless-steel saucepan, followed by cooking over medium heat for 10–15 minutes with continuous stirring. Pectin (7 g), pre-dissolved with part of the sucrose in 150 ml of hot water, was then added, and the mixture was cooked until it reached 105 °C for 20–30 minutes. Once the temperature dropped below 100 °C, 3 g of citric acid dissolved in 8 ml of room-temperature water was added. The mixture was poured into molds and allowed to set for 3–4 hours. The solidified jelly was cut into desired sizes and dried using a dehydrator at 55–60 °C for 8–12 hours until the surface was no longer sticky. The dried candies were rolled in cornstarch, individually wrapped in candy wraps, packed into standing pouches according to capacity, sealed using a heat sealer, and labeled for marketing.

2.4. Data analysis
The data obtained from sensory evaluation were statistically analyzed using one-way Analysis of Variance (ANOVA) at a 5% significance level ($\alpha = 0.05$). When ANOVA results indicated a significant effect, the analysis was continued with Duncan's Multiple Range Test (DMRT) to determine differences among treatment means [8].

3. Results and discussion
The hedonic test is a commonly used method for assessing product quality, particularly in the fields of agroindustry and food science [9]. This method is capable of producing highly accurate evaluations and, in some cases, its sensitivity may even exceed that of instrumental measurements [10]. In the present study, a hedonic test was conducted to determine the level of panelist acceptance toward the papaya

jelly candy product. The evaluation parameters included color, aroma, texture, and taste. Panelists were asked to provide their responses and rate their degree of preference for the product based on these attributes. The assessment was carried out using a scoring method by 30 untrained panelists. Each panelist received three coded jelly candy samples presented in a randomized order to minimize potential bias or perceptual errors during evaluation [11]. The final appearance of the papaya jelly candy product is shown in figure 1 and 2. The overall results of the hedonic test are presented in table 2.

Figure 1. Papaya jelly candy F1, F2, and F3

(a) (b)

Figure 2. (a) Papaya jelly candy drying process; (b) Packaged papaya jelly candy

Table 2. Average of organoleptic test results

Sample	Color	Aroma	Texture	Taste	Average
F1	5.9	5.2	6.3	6.6	6
F2	5.35	4.7	4.7	5.5	5.1
F3	5.15	4.65	5.45	5.7	5.2

3.1. Color

Color is the first parameter assessed by panelists, as it creates the initial impression when a product is visually perceived. This first impression arises because the human visual sense is the first to respond [12]. An appealing color can attract consumers and panelists, triggering curiosity and encouraging them to taste or appreciate the product. The ANOVA results for the color parameter are presented in table 3.

Table 3. ANOVA results for the color parameter

Sample	Mean	Notation
F1	5.9	a
F2	5.35	b
F3	5.15	b

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The ANOVA test for color showed significant differences between treatment F1 and treatments F2 and F3, while no significant difference was observed between F2 and F3. The highest mean score was obtained in treatment F1 (5.9, notation "a"), followed by F2 (5.35) and F3 (5.15), both with the same notation "b." This indicates that the formulation with 240 g sucrose and 360 g glucose syrup (F1) produced papaya jelly candies with a color more preferred by the panelists compared to the other formulations.

This difference is likely influenced by the sugar composition. The higher glucose syrup content in F1 contributed to clarity and color stability during cooking, resulting in a more appealing product appearance. In contrast, increasing the proportion of sucrose in F2 (300 g : 300 g) and F3 (360 g : 240 g) tended to reduce color acceptability, possibly due to sucrose's greater tendency to undergo caramelization or browning at high temperatures. This process may have caused the candies to appear darker than F1, leading to lower preference scores.

Thus, the ratio of sucrose to glucose syrup significantly affected the color acceptability of papaya jelly candies, with F1 (240 g sucrose : 360 g glucose syrup) identified as the best formulation in terms of panelist preference for color.

3.2. Aroma

The hedonic evaluation of aroma revealed significant differences between F1 and F2/F3, while no significant difference was observed between F2 and F3. The highest mean score was obtained by F1 (5.2, notation "a"), while F2 (4.7) and F3 (4.65) shared the same notation "b." This indicates that F1, with a composition of 240 g sucrose and 360 g glucose syrup, produced the most preferred aroma among the panelists. A hedonic test was also conducted on the aroma parameter, with results presented in table 4.

Table 4. ANOVA results for the aroma parameter

Sample	Mean	Notation
F1	5.2	a
F2	4.7	b
F3	4.65	b

This difference is likely influenced by the sugar ratio. The higher glucose syrup content in F1 may have helped retain papaya's characteristic aroma, as glucose acts as a flavor binder, stabilizing volatile compounds during heating. Conversely, in formulations with higher sucrose levels (F2 and F3), volatile compounds may have degraded more during heating, diminishing papaya's aroma intensity and resulting in lower aroma preference. Therefore, it can be concluded that F1 produced papaya jelly candies with the most favorable aroma, while higher sucrose proportions in F2 and F3 decreased aroma acceptability.

3.3. Texture

The hedonic evaluation of texture indicated that treatment F1 achieved the highest mean score of 6.6 with notation "a," demonstrating that the texture of jelly candies in this formulation was the most preferred by panelists. Treatments F2 (5.5) and F3 (5.7) received the same notation "b," showing no significant difference between them, but both scored lower than F1. A hedonic test on texture was also conducted, with results shown in table 5.

Table 5. ANOVA results for the texture parameter

Sample	Mean	Notation
F1	6.6	a
F2	5.5	b
F3	5.7	b

This suggests that the formulation of 240 g sucrose and 360 g glucose syrup (F1) produced a texture that was more elastic, soft, and not overly hard, aligning with panelist preferences. The differences in texture are likely due to sugar composition: sucrose contributes to crystallization and hardness, while glucose syrup prevents excessive crystallization, retains moisture, and produces a more elastic texture [12]. Furthermore, the addition of pectin and agar played an essential role in gel formation, which determined the elasticity and chewiness of the jelly candies [13]. The balance between sucrose and glucose syrup in F1 optimized gel formation and texture, making it more preferred than F2 and F3, which tended to yield harder textures due to higher sucrose content.

3.4. Taste

The hedonic evaluation of taste revealed significant differences between F1 and F2/F3, while no significant difference was observed between F2 and F3. The highest mean score was obtained by F1 (6.6, notation “a”), indicating that panelists preferred the taste of papaya jelly candies in this formulation. F2 (5.5) and F3 (5.7) shared the same notation “b,” indicating relatively lower preference compared with F1. A hedonic test was also conducted on taste, with results shown in table 6.

Table 6. ANOVA results for the taste parameter

Sample	Mean	Notation
F1	6.6	a
F2	5.5	b
F3	5.7	b

The high acceptability of F1 is likely due to the balance between 240 g sucrose and 360 g glucose syrup, which produced a sweetness that was pleasant but not overpowering, allowing the natural papaya flavor to be highlighted. While sucrose provided the primary sweetness, glucose syrup not only enhanced sweetness but also strengthened fruit flavor perception due to its hygroscopic properties, which help maintain product moisture. In contrast, higher sucrose levels in F2 (300 g : 300 g) and F3 (360 g : 240 g) resulted in a more dominant sweetness that masked papaya’s natural flavor, leading to lower taste preference among panelists. Thus, it can be concluded that F1 produced the most balanced and optimal taste, making it more preferred compared with F2 and F3.

4. Conclusions

This study demonstrated that partial substitution of sucrose with glucose syrup significantly affected the sensory quality of papaya jelly candies. Based on hedonic evaluations of color, aroma, texture, and taste, the formulation containing 240 g sucrose and 360 g glucose syrup (F1) received the highest acceptance scores from panelists compared with the other treatments. This finding indicates that glucose syrup not only reduced sucrose content but also contributed positively to improving flavor and texture acceptability. Therefore, F1 can be recommended as the best formulation for producing papaya jelly candies that are more suitable for children, both in terms of health aspects and sensory acceptance.

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