Formulation and Consumer Acceptability of Tawa–Tawa (*Euphorbia hirta*) Gummies

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ABSTRACT

Tawa–tawa (*Euphorbia hirta*) is a medicinal plant widely used in the Philippines, particularly as a traditional decoction during dengue episodes. Despite its common use, its bitter taste and strong herbal aroma limit its acceptability, especially among children and individuals who do not prefer herbal drinks. This study aimed to develop tawa–tawa gummies and determine their sensory qualities and general acceptability as affected by varying levels of tawa–tawa decoction and citric acid. A 3 × 3 factorial experimental design was used, consisting of three levels of tawa–tawa decoction (10%, 20%, and 30% w/v) and three levels of citric acid (2%, 2.5%, and 3% w/v). Nine treatment combinations were evaluated by 48 panelists using a 9–point Hedonic Scale for color, appearance, aroma, mouthfeel, sourness, sweetness, bitterness, and general acceptability. Descriptive data were analyzed using frequency and mean, while inferential analysis involved analysis of variance and contour plot analysis. Results showed that all formulations were generally acceptable. No significant differences were observed in color, appearance, and aroma, while significant differences were found in mouthfeel, sourness, sweetness, bitterness, and general acceptability. Among the treatments, the formulation containing 30% w/v tawa–tawa decoction and 2.5% w/v citric acid obtained the highest overall acceptability. The findings indicate that tawa–tawa can be successfully developed into a gummy product with acceptable sensory properties. Tawa–tawa gummies may serve as a more convenient and palatable alternative to the usual herbal decoction and may offer potential as a functional food product.

Keywords: herbal gummy, sensory evaluation, market acceptability, formulation, medicinal plant

INTRODUCTION

Tawa–tawa (*Euphorbia hirta*), also called as *gatas–gatas, magatas* or *botonis*, is a widely available herbal plant found in open grasslands and waste places throughout the Philippines. For many years, it has been used in traditional medicine, particularly as a supportive remedy for dengue fever (Cayona & Creencia 2022). Numerous testimonies from local communities report that drinking tawa–tawa decoction may help increase the blood platelets of dengue patients. According to Atienza et al. (2015), tawa–tawa contains biochemical compounds such as terpenoids, tannins, phorbic acid, fatty acids, sterols and flavonoids, including quercitrol and quercetin and their derivatives, which may contribute to its potential therapeutic effects, including increasing platelet count. Because of these perceived benefits, tawa–tawa has become one of the most commonly used herbal remedies in many Filipino households during dengue outbreaks.

Despite its popularity, the traditional method of consuming tawa–tawa through boiling and drinking its decoction is often unappealing, especially to children, because of its herbal taste and aroma (Perera et al. 2018). Hence, this creates a need for product innovations that make the consumption of herbal preparations more pleasant, convenient and acceptable to younger and more sensitive consumers.

Gummies are a type of confectionery widely known for their chewy texture and playful shapes such as bears, worms and other colorful forms. They are typically made from gelatin, pectin or other gelling agents that create a soft and elastic structure. Because of their enjoyable texture and flavor, gummies have become a popular medium for delivering vitamins, minerals and herbal extracts. The functional food industry continues to expand globally, and gummies are now commonly used as carriers for nutritional supplements because they are easy to consume, especially for children and elderly individuals who have difficulty swallowing tablets or capsules (Mutlu et al. 2018).

Given the potential health benefits of tawa–tawa and the growing trend toward functional gummies, developing tawa–tawa gummies presents an innovative strategy to make this traditional herbal remedy more palatable and accessible. Transforming tawa–tawa decoction into a gummy form may encourage intake among children and adults who dislike drinking herbal teas. Additionally, since no commercially available tawa–tawa gummy product currently exists in the market, this study addresses a gap in product innovation and contributes to the development of locally inspired nutraceuticals. This study generally aimed to develop "tawa–tawa" gummies. Specifically, it aimed to develop the formulation of the product, determine the description and acceptability of the gummies as affected by the levels of "tawa–tawa" decoction and acidification and their market acceptability.

METHODS

Procurement of Raw Materials

The Tawa–tawa plant (*Euphorbia hirta*) was freshly collected within the vicinity of Aborlan, Palawan, while other raw materials, such as glucose syrup and citric acid, were purchased locally. All materials used for product preparation were food–grade to ensure safety and quality. The collected tawa–tawa plants were manually sorted by removing the roots, wilted leaves and damaged or discolored parts. Only fresh, green leaves and tender stems were selected for use in the study. The plant was characterized by its small, hairy stems and green, oval–shaped leaves with serrated edges, as shown in Figure 1.

Figure 1. Tawa–tawa Plant (*Euphorbia hirta*) used in the study.

It typically grows in open grasslands and roadsides and contains bioactive compounds such as flavonoids, tannins, and phenolic compounds known for their antioxidant and antimicrobial properties. These characteristics made the tawa–tawa plant suitable for use as a natural ingredient, contributing to the product's preservative and health–promoting qualities.

Plant Decoction Preparation

The Tawa–tawa leaves and stalks were collected, sorted and cleaned using tap water. Roots were removed from the plant. The cleaned plant materials were weighed and decocted by boiling them in water for 15 minutes. The resulting tea was then strained using a cheesecloth and stored in a clean container. The level of plant material used was based on the experimental plan provided in Table 1.

Table 1. Factorial arrangement of tawa–tawa decoction and citric acid levels.

Citric Acid %w/v	Tawa–tawa Decoction % w/v		
	10	**20**	**30**
2	T1	T2	T3
2.5	T4	T5	T6
3	T7	T8	T9

Gummy Preparation

Tawa–tawa gummies were prepared following the method of Yan et al. (2021) with modification in measurements, the gelatin was first rehydrated in tawa–tawa tea prepared through decoction. The sugar was then mixed with a portion of the tawa–tawa tea and melted over medium heat until it turned into candy syrup. Once the sugar melted, glucose syrup was added to the mixture. When the glucose syrup was fully dissolved into the sugar syrup, the bloomed unflavored gelatin was incorporated and mixed until a smooth consistency was achieved. The prepared tawa–tawa gummy syrup was then poured into molds and refrigerated for at least 30 minutes in 40 ± 2°C (35.6°F to 46.4°F) to allow the gummies to set properly.

Experimental Design

This study employed a two–factor, 3×3 factorial design. The factors were the levels of tawa–tawa decoction (% w/v) and citric acid (% w/v). The prepared decoction was used as the base ingredient in making Tawa–tawa gummies. Table 1 presents the factorial arrangement of the different levels of tawa–tawa decoction and citric acid used in the study, which the nine treatment combinations.

Sensory Evaluation

Forty–eight (48) panelists evaluated the sensory characteristics and acceptability of the samples, following an incomplete block design (IBD) based on the Cochran and Cox experimental design. Each panelist

tasted six (6) samples out of nine (9) treatments. A sensory evaluation sheet was developed based on the initial sensory evaluation of the gummies. The sensory evaluation was conducted in two (2) replications.

Data Analysis

The data gathered from the sensory evaluation were tabulated and organized using the Design Expert 13 software and statistically analyzed through Analysis of Variance (ANOVA) to determine significant differences among treatments. Descriptive statistics such as mean and frequency were also computed to summarize the panelists' evaluation scores on color, appearance, aroma, mouthfeel, sourness, sweetness, bitterness and general acceptability of the tawa–tawa gummies.

In addition, contour plot analysis was performed to visually illustrate the interaction effects between tawa–tawa decoction levels and citric acid concentrations on the sensory attributes of the gummies. The contour plots provided a graphical representation of the response surface which allow for the identification of optimal combinations of factors that yielded the most desirable product characteristics. Lastly, the desirability factor was used to optimized the formulation based on the results of RSM analysis.

RESULTS

Gummies made with different formulation of tawa–tawa decoction and citric acid produce producs with different color and textural properties. Results in Table 2 is in accordance with the color description in Figure 2. Even with variation in color properties, the mean acceptability scores ranged from 7.09 to 7.30, indicating that all treatments were rated within the "Like Moderately" category on the 9–point Hedonic scale which means that all gummy formulations were generally acceptable to the panelists.

T1 T2 T3 T4 T5 T6 T7 T8 T9

Figure 2. Color of developed tawa–tawa gummies.

Table 2. Color description and mean acceptability scores of tawa–tawa gummies, (*Note:* ns – not significant (P–value > 0.05).

Treatment	Description	*f* (%)	Description	Mean Acceptability^{ns}
1	Reddish Brown	30.30	Like Moderately	7.18±1.50
2	Brown	28.79	Like Moderately	7.19±1.56
3	Golden Brown	30.30	Like Moderately	7.30±1.30
4	Reddish Brown	45.20	Like Moderately	7.12±1.33
5	Brown	45.31	Like Moderately	7.09±1.87
6	Golden Brown	48.44	Like Moderately	7.23±1.42
7	Reddish Brown	33.00	Like Moderately	7.14±1.21
8	Reddish Brown	37.10	Like Moderately	7.14±1.71
9	Golden Brown	41.00	Like Moderately	7.30±1.54

The appearance description and mean acceptability of tawa–tawa gummies were shown in Table 3. The mean acceptability scores of appearance ranged from 6.79 to 7.16, indicating that all treatments were rated within the "Like Moderately" range on the 9–point Hedonic Scale. The descriptive ratings show that most of the treatments were characterized as having a moderate turbidity, as described by 50% of panelists, while some were described as very weak turbid. This implies that differences in formulation influenced the clarity of the samples.

Table 3. Appearance description and mean acceptability scores of tawa–tawa gummies (*Note:* ns – not significant (P–value > 0.05).

Treatment	Description	*f* (%)	Description	Mean Acceptability^{ns}
1	Moderate Turbidity	42.42	Like Moderately	6.87±1.50
2	Moderate Turbidity	41.00	Like Moderately	7.12±1.13
3	Moderate Turbidity	45.20	Like Moderately	6.96±1.29
4	Moderate Turbidity	45.31	Like Moderately	7.00±1.07
5	Moderate Turbidity	45.31	Like Moderately	7.09±1.37
6	Very Weak Turbidity	56.30	Like Moderately	6.92±1.29
7	Moderate Turbidity	56.50	Like Moderately	6.79±1.31
8	Moderate Turbidity	45.31	Like Moderately	7.14±1.57
9	Very Weak Turbidity	34.00	Like Moderately	7.16±1.52

The aroma description and mean acceptability mean of tawa–tawa gummies as evaluated by the panelists (Table 4). All treatments were described as having a perceptible tawa–tawa aroma, implying that the characteristic aroma of tawa–tawa was noticeable across all samples with no significant difference at varying levels of tawa–tawa and citric acid.

Table 4. Aroma description and mean acceptability scores of tawa–tawa gummie, (*Note:* ns – not significant (P–value > 0.05).

Treatment	Description	*f* (%)	Description	Acceptability Mean^{ns}
1	Perceptible Tawa–tawa Aroma	27.27	Like Moderately	6.81±1.89
2	Perceptible Tawa–tawa Aroma	27.27	Like Moderately	6.89±1.30
3	Perceptible Tawa–tawa Aroma	29.03	Like Moderately	7.01±1.43
4	Perceptible Tawa–tawa Aroma	25.00	Like Moderately	6.85±1.46
5	Perceptible Tawa–tawa Aroma	26.60	Like Moderately	6.96±1.34
6	Perceptible Tawa–tawa Aroma	29.70	Like Moderately	7.00±1.28
7	Perceptible Tawa–tawa Aroma	26.00	Like Moderately	6.74±1.39
8	Perceptible Tawa–tawa Aroma	28.12	Like Slightly	6.45±1.89
9	Perceptible Tawa–tawa Aroma	26.00	Like Moderately	6.98±1.68

The mouthfeel description of the developed tawa–tawa gummies are all described with very weak astringency (Table 5). ANOVA results suggest that tawa–tawa decoction have a significant effect on the mouthfeel of the product. Figure 3 reveals that higher levels of tawa–tawa increases mouthfeel acceptability.

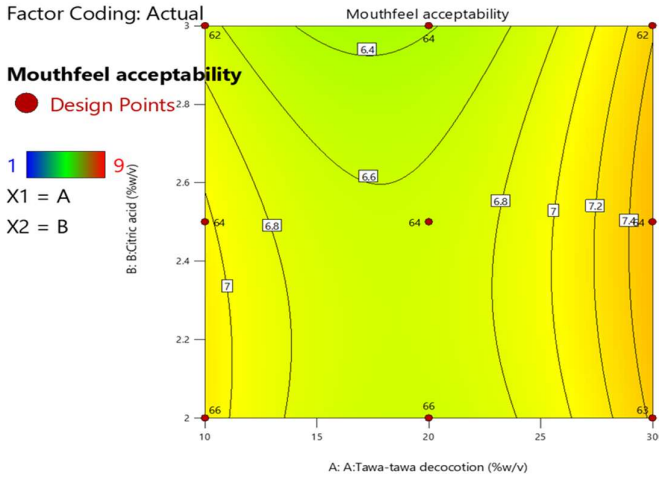

Figure 3. Contour plot showing the interaction effects of tawa–tawa decoction and citric acid levels on mouthfeel acceptability.

Table 5. Mouthfeel description and mean acceptability scores of tawa–tawa gummies, *Note:* ***–** significant difference (P–value < 0.05).

Treatment	Description	*f* (%)	Description	Acceptability Mean*
1	Very Weak Astringency	32.00	Like Moderately	7.15±1.64
2	Very Weak Astringency	28.78	Like Moderately	6.57±2.04
3	Very Weak Astringency	42.00	Like Moderately	7.48±1.45
4	Very Weak Astringency	45.31	Like Moderately	6.85±1.32
5	Very Weak Astringency	45.31	Like Moderately	6.98±1.71
6	Very Weak Astringency	39.10	Like Moderately	7.40±1.28
7	Very Weak Astringency	31.00	Like Moderately	6.80±1.47
8	Very Weak Astringency	25.00	Like Slightly	6.12±2.07
9	Very Weak Astringency	27.14	Like Moderately	7.50±1.77

The descriptive results of sourness show that most samples were perceived as sour, while others were described by the panelists as slightly sour due to the direct influence of citric acid concentration on taste intensity (Table 6). ANOVA results indicate that sourness is significantly affected by citric acid levels. As shown in the contour plot (Figure 4), sourness acceptability reached slightly higher values at moderate concentrations of both tawa–tawa decoction and citric acid. This region represents the point where panelists perceived the higher acceptability flavor.

Table 6. Sourness description and mean acceptability of tawa–tawa gummies (*Note:* ***–** significant difference (P–value < 0.05).

Treatment	Description	*f* (%)	Acceptability Description	Acceptability Mean*
1	Sour	36.36	Like Moderately	6.92±1.69
2	Slightly Sour	44.00	Like Slightly	6.31±1.84
3	Slightly Sour	35.48	Like Moderately	7.46±1.24
4	Sour	37.50	Like Moderately	6.57±1.82
5	Sour	36.00	Like Moderately	6.90±1.59
6	Sour	31.30	Like Moderately	7.21±1.56
7	Sour	31.00	Like Slightly	6.48±1.57
8	Sour	29.70	Like Slightly	6.17±2.06
9	Sour	29.03	Like Moderately	7.38±1.52

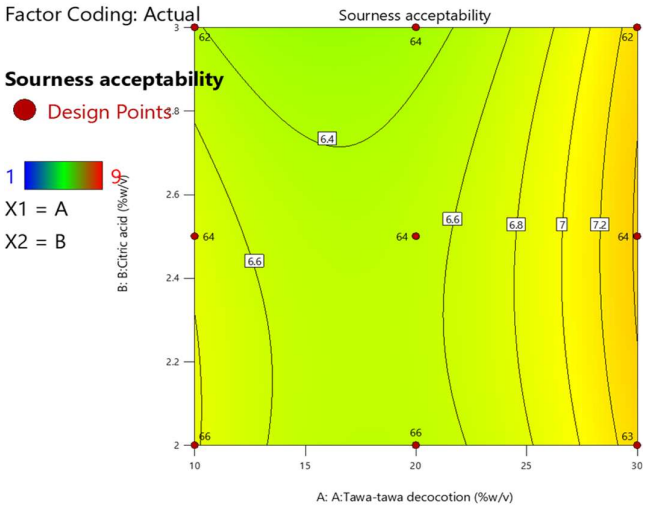

Figure 4. Contour plot showing the interaction effects of tawa–tawa decoction and citric acid levels on sourness acceptability.

Table 7 shows the sweetness description and mean acceptability of the developed tawa–tawa gummies. The mean scores ranged from 6.18 to 7.58, which correspond to the "Like Slightly" to "Like Moderately" range on the 9–point Hedonic Scale. This indicates that all treatments were generally acceptable in terms of sweetness, showing that the taste balance between sugar, glucose syrup and citric acid was pleasing to most of the panelists.

Table 7. Sweetness description and mean acceptability scores of tawa–tawa gummies, (*Note:* ***–** significant difference (P–value < 0.05).

Treatment	Description	*f* (%)	Acceptability Description	Acceptability Mean*
1	Sweet	30.30	Like Moderately	7.12±1.64
2	Sweet	32.00	Like Moderately	6.62±1.97
3	Sweet	32.25	Like Moderately	7.38±1.57
4	Slightly sweet	42.18	Like Moderately	6.82±1.34
5	Sweet	37.50	Like Moderately	6.76±2.16
6	Sweet	31.30	Like Moderately	7.35±1.48
7	Sweet	29.03	Like Moderately	6.67±1.70
8	Slightly sweet	39.10	Like Slightly	6.18±1.98
9	Sweet	27.14	Like Moderately	7.58±1.50

The sweetness description revealed that the majority of treatments were perceived as sweet, while a few were rated as slightly sweet showing that citric acid concentration affected the perception of sweetness. The contour plot for sweetness acceptability revealed a curved response surface, indicating a quadratic relationship between tawa–tawa decoction (% w/v) and citric acid (% w/v) (Figure 5). As shown in the contour plot, sweetness acceptability was highest (7.4) with the highest concentration of tawa–tawa decoction combined with a moderate level of citric acid, as indicated by the yellow orange–colored region on the right side of the plot. In contrast, the green gradient, which represents lower acceptability scores, was observed at lower tawa–tawa concentrations (between 13% to 24%) across the range of citric acid levels.

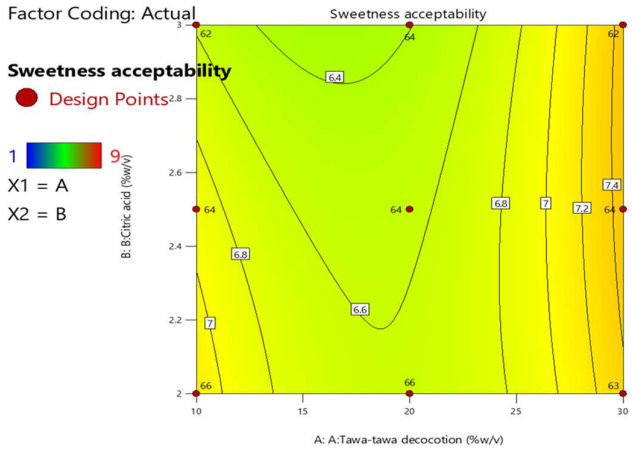

Figure 5. Contour plot showing the interaction effects of tawa–tawa decoction and citric acid levels on sweetness acceptability

The bitterness results show that some treatments were described as slightly bitter, while others were described as bitter, suggesting that the level of bitterness differs depending on the formulation (Table 8). ANOVA results revealed that bitterness acceptability is significantly affected by levels of tawa–tawa decoction. The contour plot shows that bitterness acceptability was primarily influenced by tawa–tawa concentration, with higher decoction levels (around 29%) resulting in greater liking when paired with low citric acid content (around 2.3%) (Figure 6).

Table 8. Bitterness description and mean acceptability scores of tawa–tawa gummies *Note:* ***–** significant difference (P–value < 0.05).

Treatment	Description	*f* (%)	Acceptability Description	Acceptability Mean*
1	Slightly bitter	41.00	Like Moderately	7.12±1.41
2	Bitter	33.33	Like Slightly	6.36±1.65
3	Slightly bitter	50.00	Like Moderately	7.22±1.46
4	Bitter	36.00	Like Slightly	6.14±1.39
5	Bitter	28.12	Like Moderately	6.76±1.69
6	Slightly bitter	41.00	Like Moderately	7.25±1.26
7	Bitter	27.42	Like Moderately	6.82±1.36
8	Bitter	25.00	Like Slightly	5.60±1.76
9	Slightly bitter	50.00	Like Moderately	7.35±1.49

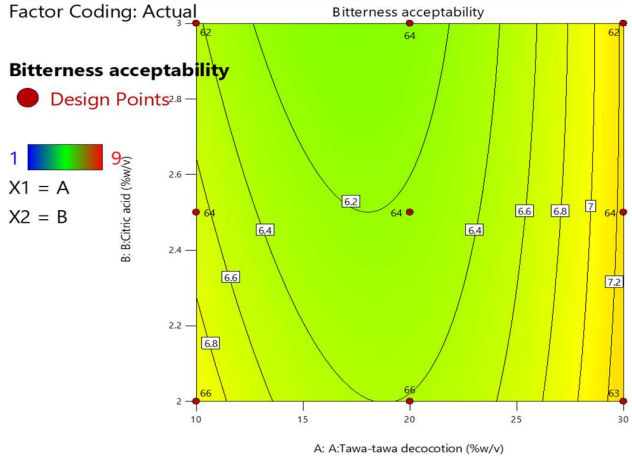

Figure 6. Contour plot showing the interaction effects of tawa–tawa decoction and citric acid levels on bitterness acceptability.

Table 9 shows the description and mean acceptability ratings of the tawa–tawa gummies in terms of general acceptability. This sensory quality represents the overall evaluation of the product by the panelists, integrating all sensory characteristics such as color, appearance, aroma, taste, sourness, sweetness, bitterness and

mouthfeel. The purpose of this evaluation was to determine which formulation achieved the highest consumer preference among the different treatment combinations.

As shown in table 9, the descriptive ratings ranged from "like moderately" to "like very much," indicating that all formulations were generally accepted by the sensory panel. The mean acceptability scores ranged from 6.56 to 7.61, signifying that the panelists found the gummies palatable and satisfactory. Treatments 1, 2, 3, 4, 5, 7, and 8 were rated as "like moderately," while Treatments 6 and 9 were rated as "like very much." The results further revealed a significant difference (P–value < 0.05) among treatments, indicating that the variation in citric acid concentration had a significant effect on the overall acceptability of the gummies. Citric acid has an important role in enhancing flavor balance by complementing sweetness, masking bitterness and providing a refreshing tartness that improves the overall sensory experience. Overall, all formulations were found acceptable, but among all treatments the best formulation was Treatment 6 which achieved the highest overall mean acceptability score (7.61) and was described as "like very much." This implies that the higher amount of decoction (30%w/v) and optimal level (2.5%w/v) of citric acid in treatment effectively enhanced the sensory balance of the gummies which make it the most desirable formulation among the tested samples.

Table 9. General description and mean acceptability scores of tawa–tawa gummies (*Note:* ***–** significant difference (P–value < 0.05).

Treatment	Description	*f* (%)	Mean Acceptability*
1	Like moderately	31.81	7.15±1.41
2	Like moderately	31.81	6.86±1.65
3	Like moderately	28.79	7.48±1.46
4	Like moderately	21.21	6.61±1.39
5	Like moderately	22.72	6.91±1.69
6	Like very much	30.30	7.61±1.26
7	Like moderately	24.24	6.98±.36
8	Like moderately	30.30	6.56±1.76
9	Like very much	31.82	7.58±1.33

DISCUSSION

Variations in color description and mean scores did not indicate a significant difference in color acceptability among treatments. The color of the candies noticeably changed and appeared darker with formulation differences (Cebin et al. 2024). However, based on the analysis of variance, the differences among the color mean acceptability scores were found to be not significant (P–value > 0.05). This means that the different levels of tawa–tawa decoction and citric acid used in the formulations did not significantly influence the color acceptability of the gummies even though color is visibly different throughout the treatments (Figure 3).

Color and appearance are closely related, they often influence how a product is perceived. Appearance is a broader visual category that includes color and other visual features such as shape, size, translucency/opacity, surface texture, gloss and uniformity, all of which contribute to the initial quality impression of the food (Carneiro et al. 2022). Thus, while color is one component, appearance is about the full set of visual cues that a consumer uses to judge a product's freshness, quality or appeal. Appearance result revealed that the differences among the treatments were found to be not significant (P–value > 0.05). This means that the variation in appearance scores was statistically insignificant, implying that the differences observed among treatments were minimal and not influenced by the formulation, which supports their potential for consumer preference and market acceptance.

Aroma of the gummies was not strongly influenced by the proportion of tawa–tawa decoction or citric acid. The perceptible aroma of tawa–tawa was likely masked by the gelatin and citric acid used in the formulation. According to Lawless (1991), aroma is a critical factor in food quality and sensory evaluation because it strongly influences flavor perception and consumer acceptance. Thus, the consistent aroma acceptability across treatments indicates that the developed tawa–tawa gummies show a favorable aromatic quality suitable for potential market preference.

Mouthfeel plays an important role in consumer acceptance of foods and beverages. Mouthfeel and texture are closely related but distinct sensory attributes of food, where texture refers to the structural, mechanical and surface properties of a product such as hardness, viscosity and smoothness perceived through the senses of sight, sound, touch and movement (kinesthetics) (Marciniak–Lukasiak et al. 2024), while mouthfeel describes the subjective physical sensations experienced specifically within the oral cavity during consumption. Mouthfeel arises from the interaction of these textural properties with chemosensory and somatosensory receptors and is primarily transmitted by the trigeminal nerve (van Eck et al. 2019). Thus, texture provides the physical foundation of a food, whereas mouthfeel represents the integrated sensory and physiological perception of that texture during eating. The findings imply that the mouthfeel of the tawa–tawa gummies was generally acceptable across all

treatments, with treatment 9 achieving the highest level of acceptability based on panelist ratings because the formulation used in this treatment resulted in gummies with the most pleasing balance of softness and mild astringency that gives a smooth and enjoyable mouthfeel. According to Ditschun et al. (2025), mouthfeel has an essential role in shaping overall sensory perception, as it integrates tactile sensations such as smoothness, cohesiveness and astringency, which strongly affect product acceptability and consumer preference.

The results on sourness revealed a significant difference (P–value < 0.05) among treatments which indicate that the different concentrations of citric acid significantly affected the perceived sourness of the gummies. This confirms that the amount of citric acid has an essential role in defining the flavor profile and sensory appeal of the product. Overall, the findings imply that the sourness of tawa–tawa gummies was influenced by the amount of citric acid added.

At higher concentrations of tawa–tawa decoction, the contour lines flattened, indicating a gradual decline in acceptability which may be attributed to the herbal bitterness of tawa–tawa that could mask the pleasant sour taste of the gummies. The unpleasant taste of tawa–tawa has been previously reported in the article of Uy (2015), describing the tawa–tawa as undesirable flavor or bitter taste comparable to "drinking soil" which discourages for consumption. Although citric acid is the main resource for the sourness of the product, its effect may have been reduced at higher decoction levels because of increased bitterness. According to Lambros et al. (2020), citric acid is positively correlated with acidity, sour taste, citrus aroma and flavor and negatively correlated with bitterness as it is commonly used to mask the bitter taste and improve palatability. Conversely, at lower concentrations, the sour taste from citric acid may not be strong enough, which is why it resulted in a slightly lower acceptability. Overall, the contour plot implies that sourness acceptability was influenced by both formulation factors, with tawa–tawa concentration having a greater influence. The relatively smooth gradient and low curvature of the plot indicate that differences among treatments were minor. However, the quadratic nature of the response implies that the best sourness acceptability was achieved at higher levels of tawa–tawa decoction and moderate levels (2.5%w/v) of citric acid, where the gummies had a balanced and pleasant sourness.

For sweetness, the differences among the treatments were found to be significant (P–value < 0.05). This implies that the amount of citric acid had a significant impact on the sweetness perception of the gummies. Citric acid, while contributing to sourness, also influences how sweetness is perceived by balancing or masking sugary flavors depending on its concentration. Overall, the findings imply that treatment 9 which achieved the highest mean score offered the most preferred sweetness among all formulations which also implies that a 3%w/v citric acid concentration provided an ideal balance between sweet and sour tastes, enhancing flavor complexity without overpowering the sweetness.

Bitterness was included to assess if the product's bitterness threshold is acceptable to consumers. There is a significant difference (P–value < 0.05) among treatments, indicating that the different levels of citric acid significantly influenced the perceived bitterness of the tawa–tawa gummies. Citric acid known for its acidity may help balance or mask the inherent bitterness of tawa–tawa extract. Treatments containing higher levels of citric acid, particularly treatment 9 (3%w/v citric acid) likely achieved better flavor harmony by reducing the perception of bitterness through acid–sweet interaction. Conversely, lower citric acid levels may have been insufficient to counteract the natural bitter compounds from the tawa–tawa plant. Overall, the results imply that the bitterness of tawa–tawa gummies decreased as the citric acid concentration increased, enhancing the product's bitterness acceptability. Treatment 9 which obtained the highest mean score was produced the most favorable flavor balance because a 3%w/v citric acid level effectively minimized bitterness and improved overall palatability.

The highest general acceptability (7.4) occurred at higher tawa–tawa decoction levels (approximately 28%) combined with a mid–range citric acid concentration (around 2.3%), as indicated by the yellow–orange region, while yellow–green areas represented lower liking scores. This implies that panelists preferred formulations with sufficient tawa–tawa to provide a recognizable herbal character without negatively affecting overall sensory perception. This result is supported by the mouthfeel, sourness, sweetness and bitterness contour plots, which consistently showed that a balanced combination of higher tawa–tawa decoction levels and moderate citric acid concentrations produced higher acceptability scores. Accordingly, general acceptability declined slightly beyond the optimal region and was also lower at very low decoction levels due to a weaker sensory profile. Overall, general acceptability was mainly influenced by tawa–tawa concentration with optimal results achieved at higher extract levels and moderate acidity which clearly identifying a balanced formulation zone.

Determining market acceptability is an important part of product development, especially for newly developed food products, because it shows whether consumers are willing to try, buy, use, and continue using the product in the market over time (Dike et al. 2025). In this study, the market acceptability test was conducted with 100 untrained participants. Acceptability was measured using a Hedonic scale, where participants rated how much they liked or disliked the product based on sensory qualities such as appearance, flavor, taste, texture, and overall acceptability. This method is commonly used because it gives a direct picture of consumer preference and the product's potential for market success.

In this study, the consumer acceptability test revealed that the majority of respondents gave positive evaluations for the developed tawa–tawa gummies. Specifically, 57% of the panelists reported that they liked the taste of the gummies, 58% indicated that they liked the flavor and 58% expressed positive general acceptability. These results were based on a 4–point Hedonic scale used in the study, where the smiling face emoji corresponds to the verbal interpretation "Like." This implies that the formulation successfully achieved appealing sensory characteristics, particularly in taste and flavor, while also satisfying overall consumer expectations.

Furthermore, 80% of respondents expressed their willingness to purchase the developed tawa–tawa gummies. This result shows that the product has good potential in the market. Willingness to purchase is an important indicator of consumer confidence and perceived value, as it goes beyond simple liking and reflects actual buying intention (Ali and Ali 2020).

Overall, the results showed that the developed tawa–tawa gummies attained good consumer acceptability and show strong potential for market.

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GENERATIVE AI STATEMENT

I hereby declare that no generative artificial intelligence (AI) tools or AI–assisted writing platforms were used in the conceptualization, data gathering, analysis, interpretation, and writing of this study.

ETHICAL CONSIDERATIONS

- Informed consents were obtained prior the sensory evaluation of this study. Studies involving human subjects must have followed the institutional and national guidelines set by the ethics board.
- Studies involving minors or children below 18 years old must have a secured consent statement form.
- Studies involving the use of animals must have also followed all institutional and national ethical guidelines for the care and use of test/experimental animals.

DECLARATION OF COMPETING INTEREST

The authors declare that there are no competing interests or personal relationships that could have appeared to influence the work reported in this paper.

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REFERENCES

Ali T, Ali J. 2020. Factors affecting the consumers' willingness to pay for health and wellness food products. Journal of Agriculture and Food Research. 2:100076.

Atienza T, Enerva L, Glifonea Z, Villamor O, Villa N. 2015. Cytotoxicity and Anti–microbial Property of the Leaf Extract of *Euphorbia hirta* (Tawa–Tawa). Open Journal of Social Sciences. 3:162–170. http://dx.doi.org/10.4236/jss.2015.33025

Carneiro R, Adie, K, Yu D, Beverly, M, Neill C, Zhang B, Duncan S. 2022. Understanding the role of overall appearance and color in consumers' acceptability of edamame. Frontiers in Sustainable Food Systems. 6:738453.

Cayona R, Creencia E. 2022. Phytochemicals of *Euphorbia hirta* L. and their inhibitory potential against SARS–CoV–2 main protease. Frontiers in molecular biosciences. 8:801401.

Dike ON, Okafor U, Nwodo SI. 2025. Promotional strategies and market acceptability of champ malt beverages in owerri municipality.

Ditschun TL, Riddell E, Qin W, Graves K, Jegede O, Sharafbafi N, Pendergast T, Chidichimo D, Wilson SF. 2025. Overview of mouthfeel from the perspective of sensory scientists in industry. Comprehensive Reviews in Food Science and Food Safety. 24:e70126. https://doi.org/10.1111/1541–4337.70126

Lambros M, Tran TH, Fei Q, Nicolaou M. 2022. Citric acid: Multifunctional Pharmaceutical Excipient. Pharmaceutics. 14(5),972. https://doi.org/10.3390/pharmaceutics14050972

Lawless HT. 1991. The sense of smell in food quality and sensory evaluation. Journal of Food Quality. 14(1):33–60. https://doi.org/10.1111/j.1745–4557.1991.tb00046.x

Marciniak–Lukasiak K, Durajczyk E, Lukasiak A, Zbikowska K, Lukasiak P, Zbikowska A. 2024. Analysis of the Impact of Reformulation of the Recipe Composition on the Quality of Instant Noodles. Applied Sciences. 14(20):9362. https://doi.org/10.3390/app14209362

Mutlu C, Tontul SA, Erbaş M. 2018. Production of a minimally processed jelly candy for children using honey instead of sugar. LWT– Food Science and Technology. 93:499–505. https://doi.org/10.1016/j.lwt.2018.03.064

Perera SD, Jayawardena UA, Jayasinghe CD. 2018. Potential Use of Euphorbia hirta for Dengue: A Systematic Review of Scientific Evidence. Journal of tropical medicine. 2018:2048530. https://doi.org/10.1155/2018/2048530

van Eck A, Hardeman N, Karatza N, Fogliano V, Scholten E, Stieger M. 2019. Oral processing behavior and dynamic sensory perception of composite foods: Toppings assist saliva in bolus formation. Food Quality and Preference. 71,497–509. https://www.sciencedirect.com/science/article/pii/S0950329318302027

Yan B, Davachi SM, Ravanfar R, Dadmohammadi Y, Deisenroth TW, Pho TV, Odorisio PA, Darji RH, Abbaspourrad A. 2021. Improvement of vitamin C stability in vitamin gummies by encapsulation in casein gel. Food Hydrocolloids. 113:106414. https://doi.org/10.1016/j.foodhyd.2020.106414

Uy J. 2015. Tawa–tawa pill maker dead serious about dengue. *Lifestyle Inquirer* [Internet]. [cited 2026 Jan 12]. Available from: https://lifestyle.inquire.net/209338/tawa–tawa–pill–maker–dead–serious–about–in

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