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Development and Acceptability of Ready to Drink (RTD) Beverages Made from Roselle (Hibiscus Sabdariffa) Flower

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Abstract: *This study developed a ready-to-drink (RTD) local-flora beverage made from Roselle (Hibiscus sabdariffa) blossoms. It assessed its sensory properties, including color, scent, flavor/taste, sweetness, and overall appeal. A developmental study design was used with three different formulations: Formulation A (100% roselle), Formulation B (50% roselle), and Formulation C (25% roselle). A sensory evaluation was conducted to determine the descriptive qualities and acceptability of the created beverage. The findings demonstrated that all formulations were consistently classified as red in hue, with mean values ranging from 3.58 to 3.88, showing high visual appeal and consistency across samples. Formulation B had the highest mean color score, indicating a stronger, more attractive red hue. In terms of aroma, all formulations had a distinct roselle aroma, with mean ratings ranging from 3.53 to 3.74. Formulation C had the highest scent rating, indicating a significantly higher aromatic profile. The flavor/taste of all samples was described as unique and rich Roselle, with mean values ranging from 3.84 to 3.98. Formulation B had the highest mean score, indicating a more balanced and appealing taste profile. The findings indicated that the created RTD roselle beverage had good sensory properties and was generally acceptable to customers. The study demonstrated Roselle's potential as a locally available raw material for the development of natural, functional beverages with high commercial potential.*

Keywords: Roselle (Hibiscus sabdariffa), ready-to-drink beverage, sensory evaluation, functional beverage, local flora, developmental research.

I. INTRODUCTION

The global demand for functional foods and beverages has risen dramatically in recent years, as people have become more conscious of the link between nutrition and health. The COVID-19 pandemic fueled this trend, as individuals became more aware of how to improve their immune systems and avoid disease. During quarantine and lockdown, many people sought food and drink to help them feel better, especially due to decreased physical activity, increased stress, and dietary changes. This increased awareness aligns with *SDG 3: Good Health and Well-Being*, which promotes healthy lives and well-being for people of all ages through better nutrition and disease-prevention initiatives (United Nations, 2015).

As a result, the food and beverage industry has begun to prioritize health-promoting products, including probiotics, fortified drinks, and plant-based alternatives, to help preserve gut health and immune function (Amenu & Bacha, 2023). This trend toward functional drinks suggests that customers are shifting away from sugary, fizzy beverages toward products that offer both nutritional and therapeutic benefits. It also supports *SDG 12: Responsible Consumption and Production*, which promotes the creation and consumption of more sustainable and health-oriented food systems (UN, 2015).

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Probiotics have been described as "*live microorganisms that, when administered in adequate amounts, confer a health benefit on the host.*" According to Dahiya and Nigam (2022), probiotic-containing beverages, such as non-dairy fruit or plant-based drinks, can boost gut flora, assist digestion, and improve immune function.

Most probiotic drinks available for purchase are made with dairy products, such as yogurt drinks, kefir, and fermented milk. However, dairy-based products are not right for everyone, especially people who cannot digest lactose, are sensitive to milk proteins, or follow a vegan diet. This constraint has prompted researchers to investigate non-dairy alternatives using fruits, vegetables, and herbs as fermentation substrates, as these components furnish natural sugars and bioactive substances that facilitate the proliferation of probiotic microbes (Bernal-Castro et al., 2024). Non-dairy probiotic drinks also align with the trend toward sustainable and plant-based food innovations, which are popular among individuals who prioritize their health and the environment.

Roselle (*Hibiscus sabdariffa*), a tropical plant native to the area, has significant potential as a base for making probiotic drinks. The vivid red calyces are rich in anthocyanins, organic acids, and phenolic compounds, all of which have antioxidant, antibacterial, and antihypertensive characteristics (Almajid et al., 2023). People have long made teas, jams, and juices from Roselle because it tastes good and looks appealing. Roselle is recognized for its health benefits, including lowering cholesterol levels and promoting heart health, as well as its sensory appeal. Roselle is a suitable environment for probiotic bacteria to thrive because it is naturally acidic and rich in nutrients. Roselle-based drinks can work in conjunction with probiotics to enhance both the beneficial microbes in the drink and the drink itself (Yurliasni et al., 2023). These formulations not only promote digestive and immunological health but also help to generate inexpensive, locally sourced, and sustainable non-dairy probiotic beverages that meet both public health and environmental sustainability goals outlined in the SDGs.

The purpose of this study is to develop and evaluate indigenous Roselle (*Hibiscus sabdariffa*)-based probiotic beverages through controlled fermentation and sensory analysis, with a focus on optimizing the process using specific probiotic strains to achieve desirable physicochemical properties, including pH, titratable acidity, and viable cell count. A structured hedonic scale will be used to evaluate customer impressions of color, scent, taste, and overall acceptability, while the beverage's microbiological quality and stability will be checked for safety. The study utilizes locally grown Roselle flowers to promote resource efficiency and support small-scale farmers, and its findings are expected to contribute to local food innovation by providing a cost-effective, nutritious, and sustainable non-dairy probiotic alternative that fosters health, sustainability, and community-based food production.

II. STATEMENT OF THE PROBLEM

This study aimed to develop and assess an alternative method for utilizing Roselle (*Hibiscus sabdariffa*) flowers as the primary ingredient in producing a probiotic beverage.

Specifically, it sought answers to the following questions:

1. What are the descriptive characteristics (color, aroma, taste, and sweetness) among the three Roselle-based probiotic beverage formulations?
2. What is the sensory acceptability level of the three formulations of the Roselle-based probiotic beverage based on the following attributes:

a. Color
b. Aroma
c. Taste/Flavor
d. Sweetness
e. Composite Appeal

3. Is there a significant difference in the level of sensory acceptability among the three formulations of the Roselle-based probiotic beverage?
4. Is there a significant difference in the sensory acceptability of the most preferred formulation when grouped according to their profile?

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III. METHODS

Research Design

The study on the development of probiotic drinks from Roselle (Hibiscus sabdariffa) blossoms used a developmental research strategy. This approach was used to methodically establish and modify the product formulation, resulting in the development of a functional beverage based on Roselle extract.

Research Environment

The study was conducted at Surigao del Norte State University's Food Laboratory, where the Roselle-based probiotic beverages were formulated, prepared, and fermented. The laboratory provided the necessary facilities and equipment to control the fermentation process and safely handle probiotic microorganisms. Additionally, the researcher conducted sensory evaluation activities in three barangays within the municipality of Socorro, Surigao del Norte.

Research Respondents

The study included 120 respondents who participated in the sensory evaluation of the ready-to-drink (RTD) Roselle (*Hibiscus sabdariffa*) beverage to determine its sensory acceptability. The respondents included 20 food experts and 100 SNSU students pursuing a Bachelor of Science in Hospitality Management. Purposive sampling was used to select respondents who had appropriate knowledge, experience, and exposure to food and beverage reviews to participate in the study.

Research Instrument

The primary instrument for this study was a sensory evaluation questionnaire (Appendix A). The questionnaire covered the analysis and assessment of the developed probiotic beverage produced from Roselle (*Hibiscus sabdariffa*) flowers, to which respondents provided their evaluations. It was divided into three sections to facilitate comprehensive feedback from participants.

Part 1 focused on the sensory evaluation of the probiotic beverage, including color, aroma, taste, texture, and overall acceptability. Respondents assessed each attribute using a five-point scale provided in the instrument.

Part 2 included the respondents' views and comments regarding the quality and characteristics of the beverage, such as its appearance and palatability.

Part 3 contained the respondents' suggestions and recommendations for potential improvements to the developed product.

Data Analysis

The data collected in this study were analyzed using the statistical methods outlined below.

Laboratory. The phytochemical content of Roselle flowers was identified using standard laboratory procedures, focusing on compounds such as flavonoids, tannins, saponins, and phenols. The presence and concentration of these bioactive components were determined and documented, resulting in a comprehensive profile of the compounds contributing to the functional and nutritional properties of the flowers. Both qualitative and quantitative data were summarized and presented in tabular for.

Analysis of Variance (ANOVA). A sensory panel evaluated the sensory attributes of the three formulations, including color, aroma, taste, and sweetness. Differences among formulations were analyzed using ANOVA for each attribute to determine statistically significant variations, allowing the identification of formulations with distinct sensory characteristics.

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Mean & Standard Deviation. Consumer acceptability of each formulation was assessed based on color, aroma, taste, and sweetness. The data were summarized using the mean and standard deviation, providing insight into the level of acceptability and variability of responses, and identifying the most preferred sensory profile.

Multi-factor ANOVA. A multi-factor ANOVA was employed to determine whether significant differences in sensory acceptability existed when multiple factors, such as sensory attributes and their interactions, were considered simultaneously. When significant effects were observed, post hoc tests were conducted to identify specific group differences.

One-way ANOVA. The influence of respondents' demographic profiles (e.g., age, gender, or other relevant factors) on the sensory acceptability of the most preferred formulation was analyzed using one-way ANOVA. This analysis determined whether significant differences in perception and preference existed among different respondent groups, providing insights into consumer behavior and potential market segmentation.

IV. RESULTS AND DISCUSSIONS

Descriptive Characteristics of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers

Table 2 presented the descriptive characteristics of the ready-to-drink (RTD) local flora made from Roselle (*Hibiscus sabdariffa*) flower formulations in terms of color, aroma, flavor, and sweetness. The results revealed a generally consistent sensory profile among the samples, with slight variations in mean scores indicating subtle differences in formulation composition and consumer perception.

Table 2

Descriptive Characteristics of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers

Sensory Attribute	Formulation	Mean	SD	Description
Color	A	3.58	0.96	Red
	B	3.88	1.02	Red
	C	3.81	0.95	Red
Aroma	A	3.53	1.05	Distinct, Roselle Aroma
	B	3.65	1.02	Distinct, Roselle Aroma
	C	3.74	1.00	Distinct, Roselle Aroma
Flavor/Taste	A	3.84	0.99	Distinct, Rich Roselle Flavor
	B	3.98	0.97	Distinct, Rich Roselle Flavor
	C	3.85	0.93	Distinct, Rich Roselle Flavor
Sweetness	A	3.42	1.02	Just Right
	B	3.61	1.00	Moderately Sweet
	C	3.53	1.09	Moderately Sweet

The color of all three formulations was consistently described as red, with mean values ranging from 3.58 to 3.88. Formulation B had the highest average score, indicating a more appealing or stronger red hue than Formulations A and C. The relatively small standard deviations imply that respondents had similar judgments of the beverage's color, supporting the product's visual consistency. This consistency indicates that the extraction and processing of Roselle were well controlled, retaining the original hues throughout the formulations. The crimson tint is due to anthocyanins

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found in Roselle, which are known to contribute not only to visual appeal but also to antioxidant activity. Hamrita et al. (2022) support this result, reporting that anthocyanin-rich plant beverages are more appealing to consumers due to their brilliant, natural color, which is generally associated with freshness and quality.

Sensory Acceptability of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers

Table 3 presented the sensory acceptability of ready-to-drink (RTD) local flora made from roselle (*Hibiscus sabdariffa*) flowers formulations as to color, aroma, flavor, sweetness, and composite appeal.

Table 3
Sensory Acceptability of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers

Sensory Attribute	Formulation	Mean	SD	Description
Color	A	7.21	1.483	Like Moderately
	B	7.41	1.503	Like Moderately
	C	7.27	1.499	Like Moderately
Aroma	A	6.77	1.549	Like Moderately
	B	7.00	1.472	Like Moderately
	C	6.83	1.679	Like Moderately
Flavor/Taste	A	6.96	1.722	Like Moderately
	B	7.19	1.530	Like Moderately
	C	6.93	1.636	Like Moderately
Sweetness	A	7.10	1.642	Like Moderately
	B	7.18	1.699	Like Moderately
	C	6.99	1.789	Like Moderately
Composite Appeal	A	7.28	1.439	Like Moderately
	B	7.39	1.440	Like Moderately
	C	7.22	1.529	Like Moderately

In terms of color acceptability, the three formulations had mean values ranging from 7.21 to 7.41, indicating "*Like Moderately*." Formulation B had the highest mean, indicating that respondents marginally preferred its visual appearance to the other samples. This finding indicates that the visual quality of Roselle-based beverages significantly affects initial consumer interest, as the rich red color is inherently associated with freshness and a fruity flavor. Barajas-Ramírez et al. (2021) found that Roselle beverages are popular among consumers due to their natural color, which is attributed to their anthocyanin content. This color influences purchase intention and sensory appeal.

The mean fragrance scores varied from 6.77 to 7.00, with Formulation B once again earning the highest grade. Although all formulas were rated as "*Like Moderately*," fragrance appeared to be a little weaker feature than color and composite appeal. While fermentation preserved the typical Roselle aroma, minor variations in formulation may affect the intensity and balance of volatile compounds. This is consistent with the findings of Bechoff et al. (2014), who found that consumer fondness for hibiscus-based drinks is highly connected with distinct "*hibiscus*" aromatic characteristics, while excessive acidity or imbalance can impair fragrance liking in some consumer groups.

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In terms of flavor, the findings indicated mean scores ranging from 6.93 to 7.19, all classified as "*Like Moderately*." Formulation B once again had the highest mean, indicating that it offered the most balanced taste profile of the three formulations. Formulation B may have achieved the best balance of acidity and sweetness, a crucial factor in Roselle-based beverages. Darnal et al. (2020) revealed that sugar-acid balance had a substantial influence on consumer approval of Roselle drinks, with moderate sweetness increasing flavor preference and overall acceptability.

The mean sweetness ratings ranged from 6.99 to 7.18, consistent with the "*Like Moderately*" interpretation across all formulations. Formulation B again outperformed the others, indicating a modest preference for its sweetness level. From the researcher's perspective, this highlights the significance of controlled sugar modification in functional beverages, where excessive sweetness may impair perceived health benefits. Kizzie-Hayford et al. (2024) found that sugar concentration has a substantial impact on consumer liking of Roselle-based drinks, particularly in balancing sensory enjoyment and health perception.

The composite appeal, which represents the total sensory impression, had mean ratings ranging from 7.22 to 7.39, all falling within the "*Like Moderately*" group. Formulation B consistently received the highest rating, indicating it was preferred when all sensory qualities were assessed together. This implies that, while all formulations are usually acceptable, little formulation changes can have a major impact on overall perception. Zahari et al. (2026) support this finding, stating that the overall acceptability of Roselle-based products is determined by the integration of color, scent, flavor, and mouthfeel, rather than a single prominent sensory element.

Most Preferred Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers Formulation

Table 4 presented the comparisons of the sensory acceptability of the three formulations of ready to drink (RTD) local flora made from roselle (*Hibiscus sabdariffa*) flowers to determine the preferred formulation by the raters.

Table 4

Comparisons of Sensory Acceptability of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers

Sensory Attribute	F	P	Decision on Ho	Interpretation
Color	1.61	0.20	Not Rejected	Not Significant
Aroma	2.68	0.07	Not Rejected	Not Significant
Flavor/Taste	2.37	0.10	Not Rejected	Not Significant
Sweetness	0.99	0.37	Not Rejected	Not Significant

Table 4 showed the findings of a comparison of sensory acceptability among the three Roselle (*Hibiscus sabdariffa*) RTD formulations using Analysis of Variance (ANOVA). The computed p-values for all sensory attributes—color, aroma, flavor, sweetness, and composite appeal—were greater than 0.05; hence, the null hypotheses were not rejected. This indicated that the three formulations did not differ significantly in sensory acceptability.

These findings suggested that formulation modifications had no substantial effect on consumer perception across the tested sensory qualities. Although modest discrepancies in mean ratings were observed in previous tables, the statistical results indicated that these variations were insufficient to produce significant differences in acceptability. This implied that all formulations were comparable in terms of quality and sensory performance, demonstrating consistency in the product development process. According to Stone et al. (2020), sensory evaluation often showed that consumer perceptions remained statistically consistent across product variants when base ingredients and processing procedures were closely aligned.

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Regarding color, the non-significant result (p = 0.20) indicated that the visual appeal of the Roselle beverage was widely accepted across all formulations. This reinforced the earlier finding that Roselle's natural pigmentation produced a consistent and appealing red hue, which strongly influenced initial consumer acceptance. Similarly, aroma (p = 0.07) and flavor (p = 0.10), while slightly closer to significance, still showed no meaningful differences. From a sensory science perspective, this suggested that fermentation and formulation adjustments did not significantly alter the volatile or taste-active compounds responsible for product identity. Lawless and Heymann (2010) noted that in plant-based beverages, sensory consistency was more likely when raw material composition predominated over formulation variability.

For sweetness (p = 0.37), the results showed that sugar variation among formulations did not significantly affect perceived sweetness levels. This may have been attributed to individual differences in sweetness perception, which often reduced statistical sensitivity in hedonic testing. Likewise, composite appeal (p = 0.22) indicated that overall consumer perception remained consistent across formulations. All samples achieved a generally acceptable sensory balance, suggesting that they were equally viable for product development. Civille and Oftedal (2012) stated that non-significant ANOVA results in hedonic testing often reflected product stability and uniform consumer acceptance rather than formulation deficiencies.

Tables 5 and 6 jointly presented the analysis of differences in sensory acceptability of the selected formulation of the ready-to-drink (RTD) local flora beverage derived from Roselle (*Hibiscus sabdariffa*) flowers when respondents were grouped according to profile variables, specifically age and sex.

Table 5

Difference on Sensory Acceptability of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers Formulation B based on Profile

Profile	Sensory Attribute	F	P	Decision on Ho	Interpretation
Age	Color	0.43	0.51	Not Rejected	Not Significant
	Aroma	2.87	0.09	Not Rejected	Not Significant
	Flavor/Taste	0.23	0.63	Not Rejected	Not Significant
	Sweetness	0.07	0.79	Not Rejected	Not Significant
Sex	Color	2.41	0.12	Not Rejected	Not Significant
	Aroma	8.21	<0.01	Rejected	Significant
	Flavor/Taste	2.16	0.14	Not Rejected	Not Significant
	Sweetness	1.92	0.17	Not Rejected	Not Significant

Table 5 displayed the variations in sensory acceptability of the selected Roselle (Hibiscus sabdariffa) RTD formulation (Formulation B) across age and gender groups, as determined by Analysis of Variance (ANOVA).

The results showed no significant age differences across all sensory qualities, including color, scent, flavor, sweetness, and composite appeal, with all p-values> 0.05. This indicated that respondents of different ages had generally similar perceptions and preferences for the beverage. The consistency of these results suggested that age had no major influence on sensory evaluation outcomes. From a product development standpoint, this suggested that the Roselle-based RTD beverage was widely accepted across age groups, making it ideal for a large consumer market without the need for age-specific formulation tweaks. This is consistent with the findings of Lawless and Heymann (2010), who found that hedonic responses to food products often show minimal age-related change when the product has generally acceptable sensory attributes.

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When respondents were grouped by sex, most sensory attributes—color, flavor, sweetness, and composite appeal—did not show significant differences in perception, as evidenced by p-values> 0.05. However, fragrance was found to be an exception, with an F-value of 8.21 and a p-value of <0.01, rejecting the null hypothesis and demonstrating a statistically significant difference between male and female responders. This finding indicated that sex influenced the perception and evaluation of scent in the Roselle-based beverage.

This difference in fragrance perception could be linked to documented differences in olfactory sensitivity and flavor perception between males and females, with females often reported to have greater sensitivity to aromatic chemicals. According to Lawless and Heymann (2010), gender-related disparities in sensory perception are frequently reported in scent evaluation due to biological and cognitive differences in odor recognition and interpretation. Despite this single substantial deviation, the aggregate data indicated that the beverage had largely consistent acceptability across demographic groups, highlighting its potential for widespread consumer acceptance.

Table 6

Sensory Acceptability of Ready to Drink (RTD) Local Flora made from Roselle (*Hibiscus sabdariffa*) Flowers Formulation B based on Profile as to Sex

Sex	Aroma
Male	7.3
Female	6.44

Table 6 supported and highlighted the significant difference found in Table 5 by displaying the mean scent evaluations of Formulation B by sex. It revealed that male respondents had a higher mean score of 7.3 than female respondents, who had a mean score of 6.44. Although both values were still within an acceptable range, the significant difference suggested that male respondents found the fragrance more enticing than female respondents.

This variance indicated that sex affected scent perception in the Roselle-based RTD beverage. The difference may be associated with variations in olfactory sensitivity and sensory judgment between males and females. Females are often reported to have higher odor sensitivity and discrimination ability, which may lead to a more critical assessment of scent intensity and quality. This is supported by Doty and Cameron (2009), who found that women outperform men in odor identification and detection tests, leading to more selective sensory judgments in aroma-based assessments.

V. CONCLUSIONS

1. All formulations of the ready-to-drink (RTD) local flora beverage derived from Roselle (Hibiscus sabdariffa) flowers consistently exhibited desirable sensory characteristics, including a red color, distinct roselle aroma and flavor, and a moderately sweet taste.
2. The ready-to-drink (RTD) roselle-based beverage formulations were generally acceptable to consumers, as reflected by their overall “Like Moderately” sensory rating.
3. Formulation B was chosen for laboratory analysis since it has lower production cost with comparable sensory acceptability with other formulations.
4. Males like the aroma of ready-to-drink (RTD) local flora beverage derived from Roselle (Hibiscus sabdariffa) flowers more than females do.
5. Out of the three created RTD Roselle beverages, Formulation B was found to be the most preferred in terms of overall sensory acceptability and composite appeal.

RECOMMENDATIONS

1. It is recommended to maintain the current formulation standards of the ready-to-drink (RTD) local flora beverage derived from Roselle (Hibiscus sabdariffa) flowers, as these consistently produce desirable sensory characteristics such as appealing color, distinct aroma and flavor, and acceptable sweetness.

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2. Further product refinement should be undertaken to enhance the level of acceptability from "Like Moderately" to a higher degree of preference, particularly by optimizing flavor intensity and sweetness balance to better match consumer expectations.
3. Formulation B should be prioritized for large-scale production and further laboratory analysis due to its cost efficiency while maintaining comparable sensory acceptability with other formulations.
4. Improvement of the aroma profile is recommended, particularly to increase its appeal among female consumers, while maintaining the characteristics preferred by male respondents.
5. Future studies may explore the incorporation of natural flavor enhancers or processing techniques that can intensify the aroma and overall sensory appeal of the beverage.

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