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Research Article

SENSORY ACCEPTABILITY OF MALUNGGAY LEAVES, WHITE CORN SEED, AND OKRA SEED POWDER AS A CAFFEINE-FREE COFFEE SUBSTITUTE

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Abstract

The increasing demand for acceptable coffee substitutes derived from locally available materials has led to the development of healthier, caffeine-free beverages. This study aimed to assess the sensory acceptability of malunggay leaf powder (MLP), okra seed powder (OSP), and white corn seed powder (WCSP) as components of a non-caffeinated coffee substitute. A descriptive sensory evaluation design was employed, involving thirty purposively selected participants grouped by age (20-30, 31-40, and 41-50 years). A structured questionnaire using a sensory hedonic scale was utilized to evaluate aroma, flavor, taste, aftertaste, and overall impression across six formulations. Data were analyzed using descriptive statistics, including mean scores, frequency, and ranking. Among the formulations, Treatment 1 (25% MLP + 25% OSP + 50% WCSP) received the highest ratings across all sensory attributes and was most preferred by participants aged 31-50 years. In contrast, Treatment 6 (20% OSP + 60% MLP + 20% WCSP) was rated as the least palatable, suggesting that higher levels of MLP may reduce acceptability. The findings indicate that varying proportions of OSP, MLP, and WCSP influence consumer acceptability, with Treatment 1 emerging as the most preferred formulation. This study contributes to the development of locally sourced, functional, and acceptable caffeine-free coffee substitutes and may serve as a basis for formulation optimization.

Keywords: Coffee substitute, Caffeine-free beverages, Food innovation, Product development, Sensory acceptability

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INTRODUCTION

Coffee is one of the most widely consumed beverages worldwide, valued for its stimulating effects due to caffeine, a central nervous system and metabolic stimulant that enhances alertness (Carag, 2019). As a major agricultural commodity, coffee is obtained from the seeds (beans) of Coffea species and is predominantly cultivated in tropical and subtropical regions, including the Philippines (Food and Agriculture Organization, 2020; International Coffee Organization, 2023). Despite its economic significance, coffee production faces multiple challenges, particularly for smallholder farmers aiming to enter the specialty coffee market. Constraints such as high capital investment, limited access to technical training, complex sustainability requirements, and stringent quality standards often restrict their participation in competitive markets (Van Touch et al., 2024).

While much research has focused on these production and market challenges, there has been limited exploration of alternative strategies that could reduce dependence on traditional coffee cultivation or create additional market opportunities. In particular, few studies have examined locally sourced, caffeine-free coffee substitutes derived from plant-based ingredients such as okra seed powder (OSP), malunggay leaf powder (MLP), and white corn seed powder (WCSP), or evaluated their sensory acceptability among consumers.

Okra (*Abelmoschus esculentus*) seeds are rich in high-quality protein, including essential amino acids, and contain beneficial oils and fiber that support digestion (Gemede et al., 2016). Malunggay (*Moringa oleifera*) leaves and seeds are rich in essential nutrients, particularly iron and vitamins A and C, and possess significant antioxidant properties that contribute to immune function, skin health, and overall physiological well-being (Mostafa et al., 2021). Corn (*Zea mays*), a widely available cereal grain, can also serve as a coffee substitute when roasted and processed through methods such as nixtamalization. Roasting and processing significantly influence its nutritional composition, including moisture, ash, crude fiber, and mineral content, suggesting that corn grains are both nutritionally viable and acceptable as a coffee alternative (Ong et al., 2024).

Although coffee substitutes made from mixtures of powdered okra, malunggay, and white corn can have nutritional and functional potential, limited research has examined the sensory acceptability of these coffee substitute powders. Most studies have studied only the individual nutritional or health properties of these ingredients, without investigating whether they might represent a palatable and sustainable alternative to traditional coffee.

Globally, coffee consumption remains substantial, with billions of cups consumed daily and global demand continuing to rise. During the 2020-2021 coffee year, consumption reached approximately 166.63 million 60-kg bags, reflecting a slight increase from the previous period (Statista Research Department, 2023). This persistent demand highlights the cultural and dietary significance of coffee, while underscoring the opportunity to develop complementary, caffeine-free alternatives.

Developing locally sourced coffee substitutes offers a promising strategy to meet the needs of health-conscious consumers while supporting smallholder farmers. Ingredients such as okra seeds, malunggay leaves, and white corn are nutrient-rich, readily available, and can be used to produce flavorful coffee alternatives. Evaluating these substitutes for sensory qualities, including taste, aftertaste, aroma, and overall acceptability, is essential to determine their market feasibility. This study, therefore, aims to formulate and assess coffee substitutes using OSP, MLP, and WCSP, providing insights into innovative products that could complement traditional coffee consumption while promoting sustainable agriculture and local livelihoods.

This study aligns with several United Nations Sustainable Development Goals (SDGs). Specifically, it contributes to SDG 2: Zero Hunger by promoting nutrient-rich crops, SDG 3: Good Health and Well-Being by providing caffeine-free, nutritionally beneficial alternatives to coffee, and SDG 12: Responsible Consumption and Production by emphasizing locally sourced ingredients and sustainable production practices.

In line with the identified research gap, this study aims to evaluate the sensory acceptability of malunggay leaf powder (MLP), okra seed powder (OSP), and white corn seed powder (WCSP) as a caffeine-free coffee substitute. Specifically, the study seeks to determine the level of sensory acceptability of the different formulations in terms of aroma, flavor, taste, aftertaste, and overall impression; compare the sensory evaluation results across the six formulations to identify the most preferred treatment; examine the differences in sensory acceptability among participants grouped according to age, and identify the optimal proportion of MLP, OSP, and WCSP that yields the highest level of consumer acceptability. This study focused on the fragrance/aroma, flavor, taste, aftertaste, and acceptability of okra, malunggay, and white corn seed powder as a substitute for coffee. Specifically, it seeks to answer what the fragrance/aroma, flavor, and taste of okra, malunggay, and white corn seed powder are as a substitute for coffee, and what the overall experience is as a coffee substitute for the respondents.

MATERIALS AND METHODS

Research Design

This study employed a descriptive research design, a method used to systematically describe the characteristics, perceptions, and responses of a group without manipulating any variables. Descriptive research focuses on observing and documenting phenomena as they naturally occur, making it appropriate for studies that aim to assess preferences, opinions, and levels of acceptability.

The use of this design was appropriate because the study aimed to evaluate the sensory acceptability of caffeine-free coffee substitutes formulated from okra seed powder (OSP), malunggay leaf powder (MLP), and white corn seed powder (WCSP). Specifically, it sought to gather panelists' perceptions in terms of aroma, taste, color, texture, and overall acceptability using a structured sensory evaluation tool.

Since a cause-and-effect relationship was intended, and the primary goal was to describe and compare the level of acceptability among different formulations, the descriptive research design provided a suitable and reliable approach for generating meaningful consumer-based insights.

A structured survey questionnaire, developed by the researchers, served as the primary data collection instrument. It was designed to evaluate the sensory attributes of each formulation, including aroma, flavor, taste, aftertaste, and overall acceptability. Responses were measured using a sensory hedonic scale adapted from the Specialty Coffee Association, enabling quantitative comparison among treatments.

The prepared formulations were presented to participants under controlled conditions. Each respondent was instructed to taste all samples and evaluate them based on the specified sensory attributes using the questionnaire. Data collection was conducted in accordance with established health and safety protocols to ensure accuracy and minimize potential bias.

The collected data were analyzed using descriptive statistical methods, including mean scores and ranking. Comparisons were conducted across formulations and age groups to determine the most preferred combination. The findings provided insights into the effects of varying proportions of OSP, MLP, and WCSP on sensory acceptability and serve as a basis for recommending an optimal caffeine-free coffee substitute.

Research Locale and Respondents

The study was conducted in Barangay Gupitan, Kapalong, Davao del Norte, a community situated in a predominantly agricultural area of the province. This location was selected due to the community's interest in local culinary innovations and agricultural products, as well as the accessibility of potential participants. The population's familiarity with plant-based food sources such as corn, okra, and malunggay made the area suitable for testing alternative coffee formulations.

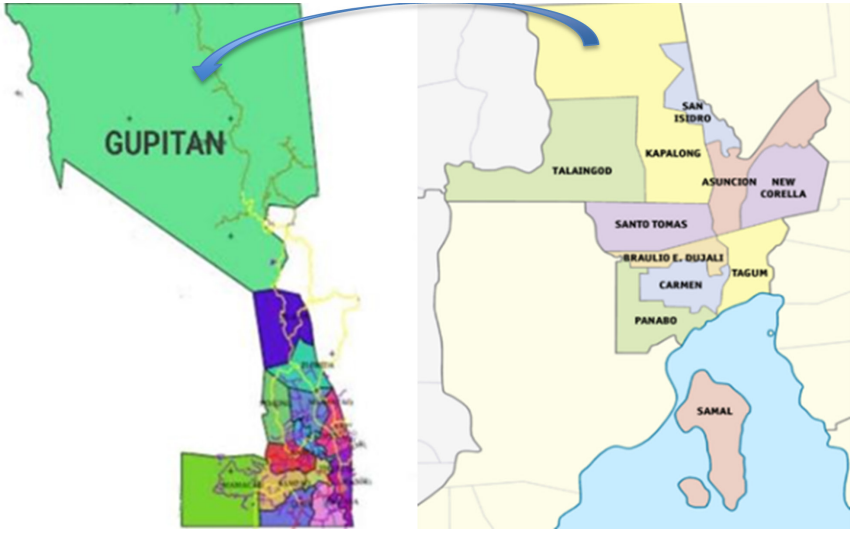

Figure 1. Map of Barangay Gupitan, Kapalong, Davao del Norte, Philippines

The study involved thirty (30) participants from Barangay Gupitan, Kapalong, Davao del Norte. Respondents were categorized into three age groups: 20-30, 31-40, and 41-50 years. A purposive sampling technique was utilized to select individuals who were regular coffee consumers or were willing to try alternative beverages.

Furthermore, the increasing demand for health-oriented beverages within the locality aligns with broader national and global trends toward functional and caffeine-free products. Conducting the study in this setting enabled the researchers to evaluate not only the sensory acceptability of the developed coffee substitutes but also their potential relevance to local consumers. This context provided valuable insights into community preferences, product feasibility, and the promotion of nutrient-dense, locally sourced alternatives.

The study involved thirty (30) participants, categorized into three age groups, to evaluate the sensory acceptability of okra seed powder, malunggay leaf powder, and white corn seed powder as a coffee substitute. Participants aged 20-30 years were generally health-conscious and receptive to innovative products, often influenced by current trends and sustainability considerations. Those aged 31-40 years tended to prioritize practicality and health benefits, particularly concerning personal and family well-being. Participants aged 41 years and above were typically more inclined toward products that align with traditional preferences and provide substantial health benefits, especially for maintaining overall wellness.

The samples were distributed directly to the participants, and guidance was provided by the researchers during the evaluation process in accordance with established procedures. This approach ensured consistency in sample presentation and adherence to the defined evaluation standards.

Research Instrument

The data gathering instrument used in this study is a survey questionnaire. This determines the evaluation of the three groups of respondents regarding the finished product's sensory attributes, such as fragrance/aroma, flavor, taste, aftertaste, and general acceptability. A sensory hedonic scale was used to evaluate the respondent's acceptability.

Based on the Specialty Coffee Association's (2003) defined sensory evaluation technique, the following parameter limitations were used to assess respondents' reactions to flavor, taste, aftertaste, fragrance/aroma, and overall acceptance. These boundaries establish structured criteria

for evaluating each sensory attribute, thereby enabling consistent and objective comparisons among various formulations.

The intensity, freshness, and desirability of the coffee substitute's scent were used to evaluate its fragrance or aroma; balance, sweetness, bitterness, and palatability were used to evaluate its flavor and taste; aftertaste was used to evaluate the sensory impression that remained after consumption, including any lingering bitterness or off flavors; and overall acceptability was used to represent the participants' overall assessment of the product. By using these well-established parameters, the sensory evaluation is designed to capture both immediate and lasting perceptions, which are important in assessing whether new coffee substitutes will be accepted by consumers.

Treatment Formulation

As indicated in Table 1, the study included six (6) formulations of caffeine-free coffee substitute utilizing different ratios of okra seed powder (OSP), malunggay leaf powder (MLP), and white corn seed powder (WCSP). These formulations were prepared to determine which combination produces the most acceptable sensory qualities in terms of aroma, flavor, taste, aftertaste, and overall acceptability. Each treatment represents a different mix of the three ingredients to assess their effect on product quality.

Table 1. Formulations of Caffeine-Free Coffee Substitute Using Okra, Malunggay, and White Corn

Treatment	Formulation
T1	25% OSP + 25% MLP + 50% WCSP
T2	50% OSP + 25% MLP + 25% WCSP
T3	25% OSP + 50% MLP+ 25% WCSP
T4	20% OSP + 20% MLP + 60% WCSP
T5	60% OSP + 20% MLP + 20% WCSP
T6	20% OSP + 60% MLP + 20% WCSP

Data Gathering Procedure

The data collection instrument employed in this study was a survey questionnaire, designed to evaluate respondents' perceptions of the finished product's sensory attributes, including fragrance/aroma, flavor, taste, aftertaste, and overall acceptability. A five-point Likert scale was used to assess respondents' acceptability and perceived marketability of the product.

The experiment involved carefully processing okra, malunggay, and white corn to create a powdered blend suitable as a coffee substitute. Each raw material underwent a systematic procedure: air drying to remove moisture, grinding to break down the materials, and pulverizing to achieve a fine, uniform texture. Afterward, the powders were accurately weighed to ensure consistency in formulation. One hundred grams of the blended coffee substitute were measured and packed into a plastic container with a label. This standardized the sample preparation for sensory evaluation, including the assessment of fragrance/aroma, flavor, taste, aftertaste, and overall acceptability.

Under the guidance of the research office, the survey questionnaire was revised as necessary. Following the establishment of its validity and reliability, written permission was obtained from the RDE Office at Kapalong College of Agriculture, Sciences, and Technology and from the respondents to administer the instrument. The validated questionnaires were then distributed to randomly selected customer respondents. Upon collection, the completed questionnaires were compiled, evaluated, and analyzed to generate the data required for the study.

The sensory evaluation of the coffee substitute made from okra, malunggay, and white corn was conducted following the guidelines of the Specialty Coffee Association (2003). Panelists assessed attributes: fragrance/aroma, flavor, taste, aftertaste, and general acceptability. Fragrance or aroma was evaluated by inhaling the brewed coffee's vapor, noting the intensity and complexity, and identifying specific scent profiles such as fruity, floral, nutty, or smoky. Flavor was judged based on the integration of taste and aroma, considering how well the flavors harmonize, the intensity of the overall flavor, and any lingering aftertaste. Taste assessment involved sipping the coffee from a cup

and allowing it to spread throughout the mouth. Aftertaste was evaluated by noting the persistence and quality of flavors that lingered after swallowing, considering both the duration and pleasantness of the remaining sensations.

Finally, general acceptability provided an overall assessment of the coffee's appeal, considering all sensory attributes and personal satisfaction. All evaluations were recorded using a Likert-type rating scale ranging from 6 to 10, where 6.00-6.99 indicated "Good," 7.00-7.99 indicated "Very Good," 8.00-8.99 indicated "Excellent," and 9.00-10.00 indicated "Outstanding."

Table 2. Sensory Evaluation Rating Scale Adapted from the Specialty Coffee Association (2003)

Rating Scale	Description
9.00-10.00	Outstanding
8.00-8.99	Excellent
7.00-7.99	Very good
6.00-6.99	Good

Data Analysis

The study uses descriptive statistics to analyze sensory evaluation data collected on a Likert scale. Sensory scores for attributes such as fragrance/aroma, flavor, taste, aftertaste, and overall acceptability were collected and organized according to age groups (20-30, 31-40, and 41-50) and were summarized into overall mean values for each treatment to provide a clear picture of respondents' preferences.

The analysis involved comparing the mean scores across treatments and age groups to identify trends, variations, and patterns in sensory perception. By highlighting the highest- and lowest-rated formulations, the researcher was able to determine which blend was most preferred and how sensory attributes differed across respondents. This method aligns with the study objectives by directly evaluating the acceptability of each coffee substitute formulation based on consumer perception, ensuring that the findings are meaningful and relevant. Conducting the analysis manually allowed the researcher to carefully interpret the results and maintain accuracy, consistency, and reliability without relying on software or statistical tools. This approach provided a robust basis for concluding the suitability and overall acceptability of the coffee substitute blends.

Ethical Considerations

This study adhered to established ethical guidelines for research involving human participants. Informed consent was obtained from all respondents before data collection. Participants were clearly informed about the study's nature and procedures, as well as the voluntary nature of their participation. They were also advised of their right to withdraw from the study at any time without any consequences.

The entire research process ensured the confidentiality and anonymity of participants. No personally identifiable information was collected or disclosed, and all responses were maintained under strict confidentiality. Data were collected solely for academic purposes and reported in summary form to prevent identification of individual respondents. Furthermore, the study was designed to ensure that participants were not exposed to any harm, discomfort, or risk during the sensory evaluation. All materials used were safe for consumption, and appropriate food safety precautions were strictly followed.

RESULTS AND DISCUSSION

Fragrance/Aroma

Fragrance/aroma refers to the perceived smell intensity and quality of the coffee substitute samples as evaluated by the sensory panel. It reflects the balance of pleasant roasted notes and undesirable vegetal or off-odors produced during processing.

Table 3. Sensory evaluation of okra, malunggay, and white corn in terms of Fragrance/Aroma as a substitute for coffee

Treatment	Age Group			Overall Mean	Descriptive Equivalent
	20-30	31-40	41-50		
T1	7.60	8.70	8.20	8.17	Outstanding
T2	7.50	7.90	7.80	7.73	Very Good
T3	7.70	7.80	7.30	7.60	Very Good
T4	7.20	7.60	7.40	7.40	Very Good
T5	7.80	7.20	7.30	7.43	Very Good
T6	7.10	7.00	7.40	7.17	Very Good

Table 1 shows that Treatment 1 (25% OSP, 25% MLP, 50% WCSP), described as “outstanding,” obtained the highest mean rating for fragrance/aroma. This suggests that this formulation produced a more acceptable aromatic profile, likely due to a balanced release of volatile compounds during roasting. The combination may have reduced undesirable vegetal or grassy odors while enhancing roasted and nutty notes commonly associated with coffee.

In contrast, Treatment 6 obtained the lowest mean rating, although it remained within an acceptable range. This may be attributed to the higher proportion of malunggay leaf powder and other plant-based components, which could contribute stronger herbal or green aroma notes. Such results indicate that increasing the level of certain plant materials may negatively affect aroma acceptability due to dominant volatile compounds. The relatively close ratings among Treatments 2 to 5 suggest that moderate variations in formulation do not substantially affect aroma perception, provided that off-odors remain controlled. This implies that aroma acceptability is more sensitive to extreme formulation changes rather than minor adjustments in ingredient ratios.

The results indicate that Treatment 1 (25% OSP, 25% MLP, 50% WCSP) received the highest preference for fragrance/aroma, suggesting that this combination of okra seed powder, malunggay leaf powder, and white corn seed powder was particularly desirable to consumers. The higher acceptability may be attributed to the balanced development of volatile compounds during roasting, which are known to influence aroma perception in coffee substitutes. This optimal ratio of ingredients likely minimized undesirable vegetal or grassy notes while enhancing roasted and nutty characteristics that are commonly preferred in coffee-like beverages.

The relatively lower mean rating of Treatment 6 suggests that higher inclusion levels of plant components, particularly malunggay leaf powder, may intensify herbal or green aroma notes that reduce consumer acceptability. This aligns with findings that volatile compound composition and aroma quality in coffee and coffee-like beverages are strongly influenced by processing conditions and raw material composition, which determine the balance of desirable and undesirable aroma-active compounds (Vezzulli et al., 2023).

In addition, the preference for Treatment 1 among respondents aged 31-40 may reflect differences in sensory expectations and familiarity with traditional coffee aroma profiles. Consumer adoption is highly determined by the similarity of these alternatives to traditional coffee, especially regarding roasted aroma and off-odors (Mostafa et al., 2021). This is consistent with current findings, whereby formats perceived to be more balanced in their aromatic properties obtained higher ratings. The relatively close scores between Treatments 2 to 5 indicate that modest differences in formulation do not dramatically alter aroma acceptability, as long as undesired volatile compounds can be controlled. And this observation agrees with Chung et al. (2022). The extent of these effects strongly depends on processing conditions and interactions of ingredients.

Furthermore, the results support the findings of Poláková et al. (2023), who demonstrated that pleasant aroma attributes (roasted, nutty) enhance consumer liking, while beany or vegetal odors reduce it. The present study extends this knowledge by identifying acceptable aromatic profiles for okra, malunggay, and white corn locally available raw materials when properly formulated.

These results show the importance of adjusting ingredient ratios and preparation methods to improve the aroma of caffeine-free coffee alternatives. This is important for product development because it helps create formulations that meet consumer preferences while using sustainable, plant-based ingredients.

Flavor

Flavor refers to the overall taste perception of the coffee substitute, including the combined sensations of basic tastes (such as bitterness and slight sweetness) and other mouth-perceived characteristics that contribute to acceptability. Table 4 presents the mean sensory evaluation ratings of the different treatments in terms of flavor as assessed by the respondents across age groups.

Table 4. Sensory evaluation of okra, malunggay, and white corn in terms of flavor as a substitute for coffee

Treatment	Age Group			Overall Mean	Descriptive Equivalent
	20-30	31-40	41-50		
T1	8.30	8.70	8.50	8.50	Excellent
T2	7.60	7.90	7.40	7.63	Very Good
T3	7.20	7.80	7.20	7.40	Very Good
T4	7.60	7.30	7.40	7.43	Very Good
T5	7.90	7.10	7.60	7.53	Very Good
T6	6.70	6.60	6.90	6.73	Good

As shown in Table 4, Treatment 1 obtained the highest mean score (8.50), described as “Excellent,” indicating that it was the most preferred formulation in terms of flavor. This suggests that the specific ratio of okra seed powder, malunggay leaf powder, and white corn seed powder produced a well-balanced flavor profile. The desirable taste may be attributed to the interaction of flavor-active compounds formed during roasting. On the other hand, Treatment 6 received the lowest mean score (6.73), although still within the “Good” category. This lower rating may be due to the higher proportion of malunggay leaf powder and other plant-based components, which can contribute stronger herbal and bitter undertones when present in excessive amounts. Such an imbalance in flavor components can lead to less desirable organoleptic properties and reduced consumer acceptability.

Furthermore, the relatively close mean scores of Treatments 2 to 5, all described as “Very Good,” indicate that moderate variations in formulation do not significantly affect flavor acceptability as long as no single component dominates the overall taste. This implies that maintaining balance among ingredients is more critical than minor formulation differences. The higher preference for Treatment 1 among respondents aged 31-40 suggests that this formulation may better approximate the flavor characteristics of traditional coffee, particularly the balance of acidity, bitterness, and subtle sweetness that consumers expect.

These findings are consistent with Seninde and Chambers (2020), who reported that bitterness and astringency in coffee are influenced by acid composition, which plays a crucial role in flavor perception. Yeager et al. (2021) further explained that organic acids such as citric, malic, and quinic acids contribute significantly to flavor complexity. Chung et al. (2022) emphasized that taste is a primary driver of consumer acceptance, strongly influenced by ingredient composition. Similarly, Jaeger et al. (2024) noted that raw material sources affect flavor characteristics detectable in sensory evaluations. Studies by Gorjanović et al. (2017) support that plant-based formulations contain diverse volatile and phenolic compounds that influence flavor and overall sensory quality. Moreover, Mostafa et al. (2021) emphasize that balance in flavor is a key determinant of consumer liking in coffee substitutes.

The results further emphasize that flavour acceptability is more sensitive to exacting ingredient proportions and processing conditions, even for caffeine-free coffee substitutes. In this sense, it is essential to develop a balanced and similar profile able to mimic the patent sensorial characteristics of conventional coffee in order to encourage acceptance by consumers and promote competitive plant-based substitutes.

Taste

Taste refers to the basic gustatory perception of the coffee substitute, particularly the balance of bitterness, sweetness, and other taste components that contribute to overall acceptability. Table 5 presents the mean sensory evaluation ratings of the different treatments in terms of taste as assessed by respondents across age groups.

Table 5. Sensory evaluation of okra, malunggay, and white corn in terms of Taste as a substitute for coffee

Treatment	Age Group			Overall Mean	Descriptive Equivalent
	20-30	31-40	41-50		
T1	8.20	8.40	8.50	8.37	Excellent
T2	7.90	7.50	7.30	7.57	Very Good
T3	7.30	7.70	7.70	7.57	Very Good
T4	7.40	7.60	7.50	7.50	Very Good
T5	8.00	6.80	8.00	7.60	Very Good
T6	7.10	6.70	6.90	6.90	Good

As shown in Table 5, Treatment 1 (25% MLP + 25% OSP + 50% WCSP) obtained the highest mean rating (8.37), described as “Excellent,” indicating that it was the most preferred formulation in terms of taste. This suggests that the specific combination of ingredients produced a well-balanced taste profile. The acceptability of this treatment may be attributed to the harmonious integration of bitterness and slight sweetness, along with desirable roasted characteristics, resulting in a flavor comparable to conventional coffee. This reflects sensory balance, where no single taste component dominates the overall perception.

The relatively higher ratings from respondents aged 41-50 further suggest that this formulation aligns with the taste preferences of older consumers, who may be more familiar with traditional coffee profiles characterized by moderate bitterness and less pronounced sharpness. In contrast, Treatment 6 received the lowest mean score (6.90), although still within the “Good” category. This lower rating may indicate an imbalance in ingredient composition, particularly due to higher concentrations of malunggay leaf powder, which may contribute stronger bitter and earthy notes. Such an imbalance can negatively affect taste acceptability. Meanwhile, the relatively similar ratings among Treatments 2 to 5, all described as “Very Good,” indicate that moderate variations in formulation do not significantly affect taste as long as the balance among taste components is maintained. This suggests that excessive bitterness or undesirable aftertaste must be controlled to ensure acceptability.

These findings are consistent with Gorjanović et al. (2017), who reported that polyphenolic compounds in plant-based coffee substitutes contribute to bitterness and astringency, thereby influencing taste perception. Similarly, Mostafa et al. (2021) emphasized that bitterness, sweetness, and roasted characteristics are key determinants of consumer acceptance in coffee alternatives. The results further support the idea that the chemical composition and interaction of ingredients play a critical role in shaping taste and overall sensory quality. Taste acceptability of coffee substitutes depends not only on individual ingredients but also on their interactions and overall balance. Given that consumers have specific preferences regarding product characteristics and performance, formulations must be carefully optimized to achieve a product that meets these expectations.

Aftertaste

Aftertaste refers to the residual sensory impression left in the mouth after swallowing the coffee substitute, particularly the persistence and quality of lingering flavors such as bitterness, sweetness, or undesirable earthy notes. Table 6 presents the mean sensory evaluation ratings of the different treatments in terms of aftertaste as assessed by respondents across age groups.

Table 6. Sensory evaluation of okra, malunggay, and white corn in terms of Aftertaste as a substitute for coffee

Treatment	Age Group			Overall Mean	Descriptive Equivalent
	20-30	31-40	41-50		
T1	8.30	8.20	8.60	8.37	Excellent
T2	7.80	7.60	8.60	7.73	Very Good
T3	7.30	8.20	7.10	7.53	Very Good
T4	8.00	7.20	7.60	7.60	Very Good
T5	8.50	6.80	7.60	7.63	Very Good
T6	6.90	6.90	7.10	6.97	Good

As shown in Table 6, Treatment 1 (25% MLP + 25% OSP + 50% WCSP) obtained the highest mean rating (8.37), described as “Excellent,” indicating that it was the most preferred formulation in terms of aftertaste. This suggests that the specific composition produced a more pleasant and balanced residual sensory impression. The result implies that the formulation was able to minimize undesirable lingering bitterness or astringency while maintaining a smooth and coherent flavor transition after swallowing.

The relatively higher ratings from respondents aged 41-50 further suggest that this formulation may better resemble the aftertaste characteristics of traditional coffee, which is typically described as having a mild bitterness with a clean finish. This indicates that familiarity with conventional coffee may influence perception of residual flavor quality.

In contrast, Treatment 6 (20% OSP + 60% MLP + 20% WCSP) received the lowest mean score (6.97), although still rated as “Good.” This may indicate that an imbalance in ingredient proportions, particularly the higher level of malunggay leaf powder, contributed to stronger lingering earthy or bitter notes that reduced aftertaste acceptability.

Meanwhile, the relatively close ratings among Treatments 2 to 5, all categorized as “Very Good,” suggest that moderate variations in formulation do not significantly alter aftertaste quality as long as overall balance among ingredients is maintained. However, these formulations may not yet achieve the optimal smoothness and clean finish observed in Treatment 1.

These findings are consistent with Mostafa et al. (2021), who emphasized that bitterness and astringency-related compounds significantly influence residual sensory perception in plant-based beverages. Similarly, Chung et al. (2022) noted that aftertaste is a key determinant of consumer acceptance, particularly in coffee and coffee-like products. Torma et al. (2019) further emphasized that residual sensory attributes are important distinguishing factors among coffee substitutes, affecting overall product preference. In addition, Lee et al. (2025) observed that chemicals that develop during the volatile phase of processing affect mouthfeel, overall taste progression over time, and some early flavor notes.

The results indicate that aftertaste acceptability is strongly influenced by ingredient balance and processing interactions. A well-balanced formulation produces a smoother and more pleasant residual sensory experience, with Treatment 1 achieving the most favorable outcome among all formulations.

Overall Acceptability

This refers to the general sensory preference of the coffee substitute as evaluated by respondents, based on the combined effects of aroma, flavor, taste, and aftertaste. Table 7 presents the mean sensory evaluation ratings of the different treatments in terms of overall acceptability as assessed by respondents across age groups.

Table 7. Sensory evaluation of okra, malunggay, and white corn in terms of overall acceptability as a substitute for coffee

Treatment	Age Group			Overall Mean	Descriptive Equivalent
	20-30	31-40	41-50		
T1	8.60	8.50	8.20	8.60	Excellent
T2	8.10	7.90	7.70	8.10	Excellent
T3	7.20	8.00	7.50	7.20	Very Good
T4	7.30	7.60	7.10	7.30	Very Good
T5	8.00	7.50	7.20	8.00	Excellent
T6	7.20	6.50	7.30	7.20	Very Good

Treatment 1 (25% MLP + 25% OSP + 50% WCSP) obtained the highest mean rating as shown in Table 7, indicating that it was the most preferred formulation in terms of overall acceptability. This suggests that the combined sensory attributes of aroma, flavor, taste, and aftertaste were most harmonized in this formulation. The result implies that overall acceptability is influenced by the integration and balance of multiple sensory characteristics rather than a single dominant attribute.

The relatively high ratings from respondents aged 20-30 and 31-40 suggest that Treatment 1 is well accepted by both younger and middle-aged consumers. This may be due to its balanced sensory profile, which minimizes undesirable attributes such as excessive bitterness and strong vegetal notes. This indicates that familiarity with coffee-like sensory qualities and openness to plant-based alternatives may enhance product acceptability when sensory balance is achieved.

In contrast, Treatment 6 obtained lower acceptability ratings, although still within the “Very Good” category. This suggests that an imbalance in ingredient composition may negatively affect the overall sensory experience, particularly through the presence of stronger undesirable taste, aroma, and aftertaste notes. Meanwhile, Treatments 2, 3, 4, and 5 were also rated within acceptable ranges, indicating that moderate variations in formulation still produce generally acceptable products. However, these formulations may not achieve the same level of sensory harmony observed in Treatment 1, which explains its higher overall preference.

These findings are consistent with Mostafa et al. (2021), who reported that consumer acceptance of plant-based beverages depends on the integration and balance of sensory attributes, where no single characteristic should dominate the overall profile. Yeager et al. (2021) also noted that flavor perception and overall sensory acceptance are influenced by chemical components that contribute to taste complexity and balance. In addition, Gorman et al. (2021) found that undesirable earthy and bitter notes negatively affect consumer acceptance, while more balanced sensory profiles enhance overall liking and preference.

The results indicate that the acceptability of caffeine-free coffee substitutes relies on the successful combination of numerous sensory attributes, and not just a single factor. The processing conditions and proportions of ingredients were better balanced in Treatment 1 than in Treatments 2-5, an affirmation that the balance of components is key to creating a product that meets consumer expectations. Moreover, the fact that it received similar ratings from consumers of different age groups demonstrates its capacity for broader market acceptance and application as a credible plant-based coffee substitute.

CONCLUSION

Among all treatments evaluated, Treatment 1 (25% malunggay leaf powder + 25% okra seed powder + 50% white corn seed powder) achieved the highest sensory acceptability for aroma, flavor, and taste, indicating that a balanced combination of ingredients is critical for consumer preference. In contrast, Treatment 6, which contained the highest proportion of MLP, received the lowest ratings, demonstrating that increasing certain ingredients may negatively affect palatability. Treatments 2 and 3 received moderate acceptability scores, and the observed consumer preferences further support the differentiation in acceptability among formulations.

The study also examined the influence of demographic factors, particularly age, on sensory evaluation outcomes. Older respondents showed a stronger preference for well-balanced formulations, highlighting the importance of taste sensitivity and consumer profiling in product development. These findings underscore the need to tailor formulations according to target consumer characteristics.

The results demonstrate the feasibility of developing sustainable, health-promoting alternatives to conventional coffee using locally sourced, caffeine-free ingredients. The study indicates potential applications in food innovation, agricultural diversification, and community-based enterprise development. Future research should focus on comprehensive nutritional analyses, microbiological safety assessments, physicochemical characterization, and large-scale production trials to ensure product quality, safety, and commercial viability.

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Conflict of Interest

The authors declare no conflicts of interest, financial, professional, or personal, that could have influenced the study's design, data collection, analysis, or interpretation. This research was conducted independently and received no support from any commercial entity, manufacturer, or organization that could benefit from its outcomes.

All materials used in the formulation of coffee substitutes, including okra seed powder, malunggay leaf powder, and white corn seed powder, were prepared solely for academic research purposes. The sensory evaluation was conducted objectively using structured procedures, and the findings were reported transparently and without bias.

The authors affirm that no competing interests exist that could have affected the design, execution, or reporting of this study.

Ethical Statement

This study complied with established ethical standards for research involving human participants. Written informed consent was obtained from all respondents before they participated in the sensory evaluation. The research protocol was reviewed and approved by the Ethics Review Committee, ensuring adherence to institutional and national ethical guidelines.

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