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Optimization of Roasting Temperature for the Formulation of Adlai *(Cix Lacryma-Jobi L.)* – Based Drink

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Index Terms:

Adlai grains, roasting temperature, sensory evaluation, cost-return analysis

Abstract. This study focused on the formulation, sensory evaluation, and economic viability of an adlai-based beverage made from roasted adlai grains. Four formulations were prepared by roasting the grains for 40 minutes at varying temperatures to determine the effect of roasting on sensory quality and acceptability. The beverage samples were standardized using 9 grams of roasted adlai per 250 mL of water and evaluated by 75 untrained panelists using a 9-point hedonic scale. Results showed significant differences among the formulations in terms of appearance, aroma, texture, flavor, and overall acceptability. Formulation I, roasted at the lowest temperature, received the lowest ratings, while Formulation II obtained neutral acceptability. Formulations III and IV achieved the highest sensory scores, indicating that higher roasting temperatures improved the beverage's quality. Formulation III, roasted at 200°C, was identified as the most acceptable due to its balanced flavor, aroma, texture, and appearance. Economic analysis revealed that all formulations were profitable, with ROI values exceeding 100%. Although Formulation I had the highest ROI because of lower production costs, Formulation III was recommended for commercialization because of its superior consumer acceptability and market potential. The findings highlight the importance of optimizing roasting temperature in producing a marketable adlai-based beverage.

Introduction

Due to the growing need for gluten-free, nutritionally adequate, and ecologically friendly alternatives to regular staple grains, ancient and underused crops have gotten more attention. Adlai (Coix lacryma-jobi L.), also known as Job's Tears, is one of these crops. It has been recognized for its potential to help with food security and the development of functional foods (Lee et al., 2016; Gerpacio & Castillo, 2021). Functional products such pasta using adlai flour (Aquino & Cruz, 2021), cereal bars using adlay grains (Juliano & Bagabaldo, 2024) and cereal-based milk drink, (Manning, Cruz, & Navarro, 2019).

Adlai is a nutrient dense diet rich in several critical minerals, such as calcium, iron and phosphorus, as well as protein and fiber. It is a suitable choice of diet for people with celiac disease or gluten sensitivity, who must thus avoid cereals containing gluten (*Woodward*, 2007; *Palavecino et al.,* 2017). This is because it is naturally free of gluten The increasing popularity of gluten-free diets due to health issues and personal choices (*Bustos et al*., 2015; *Hager et al.,* 2012) has created a demand for new and acceptable gluten-free food and beverage products.

Rice is still the most important staple grain in the Philippines according to the Department of Agriculture in 2020. However, rice production is being hampered by a number of challenges including the changing climate, limited water availability, land conversion and the uncertainty of market conditions. In response, the Department of Agriculture (DA) and the Bureau of Agricultural Research (BAR) acknowledged adlai as a climate-resilient and underutilized grain. Adlai has the capability to thrive in upland and marginal environments with minimal inputs (DA-BAR, 2020; *Weng et al.*, 2022). Government programs have prompted the planting of adlai in the province of Bukidnon, the Cordillera Administrative Region and other parts of Mindanao. This opens the possibility of adlai as a valuable grain source with great nutritional and economic value (*Arcalas, 2022; Paquit,* 2022).

Most of the researches conducted for adlai have been on its use as an alternative to rice, ingredient in flour, or a conventional food product (*Lee et al*., 2016; *Gerpacio and Castillo*, 2021). While the market desire for non-caffeinated and functional beverage alternatives is increasing, limited study has been done on the incorporation of caffeine into beverage products, especially beverage types similar to coffee. *Green & Cellier* (2007) and *Sciarini et al.* (2012) indicate that there are still many barriers to overcome before gluten-free beverages may be developed that have sensory attributes comparable to those of ordinary grain-based beverages.

The study of development and testing of an adlai based beverage to determine customer acceptability is timely and relevant. This type of research aids in the long-term agricultural expansion of the Philippines, helps in creating a new food product, and promotes the use of crops that are not fully utilized.

Although a large number of studies have been done on adlai (*Coix lacryma-jobi L.*) for its nutritional composition, agronomic performance, and potential as a flour-based ingredient or staple food, very little research has been done on its use in brewed beverages. The present study provides some empirical information on the formulation and sensory acceptance of beverages from adlai, particularly in the Philippine environment.

This study tackles this gap by designing and analyzing an adlai-based beverage using controlled formulation and sensory acceptability testing. It contributes to the existing body of knowledge by adding new information to the existing body of knowledge by providing local data on the potential of roasted adlai as a basis for beverage development at different roasting temperatures and processing circumstances.

Statement of the Problem

This study aimed to formulate an Adlai (Coix lacryma-jobi L.)-based beverage and evaluate its sensory acceptability and sensory characteristics. Specifically, it sought to answer the following questions:

1. What is the level of consumer acceptability of the four Adlai-based beverage formulations in terms of appearance, aroma, texture, and flavor?
2. What significant differences exist in the level of consumer acceptability among the four Adlai-based beverage formulations in terms of appearance, aroma, texture, and flavor?
3. Which among the four formulations is the most acceptable in terms of general acceptability across the different roasting temperatures?
4. What is the sensory profile of the most acceptable Adlai-based beverage formulation in terms of:
    a. appearance and color;
    b. aroma intensity;
    c. flavor;
    d. body; and,
    e. aftertaste?
5. What Information, Education, and Communication (IEC) material can be developed to promote the most acceptable formulation of the Adlai-based beverage?
6. What is the estimated return on investment of the four adlai-based beverage formulations based on the conducted cost and return analysis?

Methodology

Materials and Methods

This section presents the materials and methods used in developing the Adlai-based drink. It covers the preparation of ingredients, tools, and equipment, along with the step-by-step procedure followed to ensure product quality, consistency, and efficiency. The process starts with the selection and preparation of Adlai grains and concludes with the formulation of the final drink.

A. Preparation of Ingredients
Table 1 shows the ingredients used in making one cup of the adlai-based beverage, along with their exact measurements for each of the four formulations.

Formula	Ingredients	Quantity
I	Treated Adlai Powder	9 grams
	Water	42 grams
	Honey (Optional)	250 grams
II	Treated Adlai Powder	9 grams
	Water	42 grams
	Honey (Optional)	250 grams
III	Treated Adlai Powder	9 grams
	Water	42 grams
	Honey (Optional)	250 grams
IV	Treated Adlai Powder	9 grams
	Water	42 grams
	Honey (Optional)	250 grams

Table 1. Ingredients in Making Adlai-based Drink

Each formulation includes treated Adlai powder, water, and honey as an optional sweetener. As presented, all four formulations follow the same proportions: 9 grams of treated Adlai powder, 250 grams of water, and 42 grams of honey. Using the same measurements helps keep everything consistent across all formulations. Because of this, any differences observed in the final drink can be attributed to factors other than the ingredients themselves. Honey is also added as an optional ingredient, giving room to adjust the flavor according to personal preference.

A. Preparation of Tools and Equipment
Table 2 presents the tools and equipment used in the study and their specific functions in each stage of the process.

Experimental Tools / Equipment	Experimental Functions
Billow	It was used to store Adlai grains for natural drying under sunshine.
Frying Pan	This roasting equipment was used to control heat and increase the flavor, aroma, and texture of Adlai grains.
Gas Stove	It was the appliance that regulated dry heat to roast Adlai grains.
Measuring Spoon	It was used to measure Adlai powder.
Weighing Scale	This tool was used to accurately measure Adlai powder to ensure consistency and uniformity throughout all formulations or processes.

Table 2. Experimental Tools and Equipment

The billow was used to store the Adlai grains during natural sun drying to allow adequate air circulation and protection from contaminants. For the roasting stage, a frying pan and gas stove were utilized to apply and regulate dry heat, which helped enhance the grains' flavor, aroma, and texture. Measurement tools such as the measuring spoon and weighing scale were employed for precise and consistent quantities of Adlai powder across all formulations.

B. Experimental Adlai Powder Formulation
Table 3 presents the different formulations used in the production of Adlai powder. It shows variations in adlai grain condition, granulation state, roasting time, brewing method, and temperature. All samples used 1000 g of Adlai grains and were roasted for the same amount of time, which is 40 minutes. After roasting, they were prepared following the farmer's usual practice, using simple methods like boiling or stirring the roasted Adlai in hot water. The main differences between the formulations can be seen in how finely the grains were processed and the roasting temperature applied.

Adlai-Powder Treatments					
Formulation	**Adlai Grain (g)**	**State of Granulation**	**Roasting Time**	**Roasting Temperature (°C)**	**Brewing Method**

I (Control)	1000 g	Non-Granulated	40 minutes	100	Farmer's Practice
II	1000 g	Granulated	40 minutes	150	Farmer's Practice
III	1000 g	Granulated	40 minutes	200	Farmer's Practice
IV	1000 g	Granulated	40 minutes	250	Farmer's Practice

Table 3. Formulation in the Production of Adlai Powder

Formulation I (the control) used non-granulated Adlai grains and was processed at 100°C. Formulations II, III, and IV used granulated Adlai grains and were subjected to increasing roasting temperatures of 150°C, 200°C, and 250°C, respectively. These variations were set to examine how changes in roasting temperature affect the characteristics of the resulting Adlai powder.

A. Procedure in Formulating Adlai-Based Drink

As shown in Figure 2, the preparation of the Adlai-based drink begins with the selection of raw materials, particularly the harvesting and sorting of Adlai grains. During this stage, only fully matured and good-quality grains are selected, while those that are defective, immature, or damaged are set aside.

After selection, the grains undergo milling to break them down into smaller particles to make them more suitable for further processing. The milled grains are then subjected to sun-drying for 6-10 days, depending on the weather, to lower their moisture content. At this point, the grains are checked to see if they have reached the desired level of dryness. If they are still too moist, they are returned for further drying to avoid spoilage and to ensure they roast properly later on. Once the grains are adequately dried, they are ready to move on to the next stage.

The dried grains are then roasted, an important step as it significantly enhances the flavor, aroma, and color of the Adlai-based drink. Roasting develops the characteristic sensory properties of the product to make it more appealing to consumers. Following roasting, the process branches into different formulations. Formula I is retained in its current form, while Formulas II, III, and IV undergo an additional granulation process. After the formulation stage, the processed Adlai powder is carefully weighed to ensure uniformity across all samples. The powder is then properly packaged to preserve its quality, protect it from contamination, and maintain its shelf life.

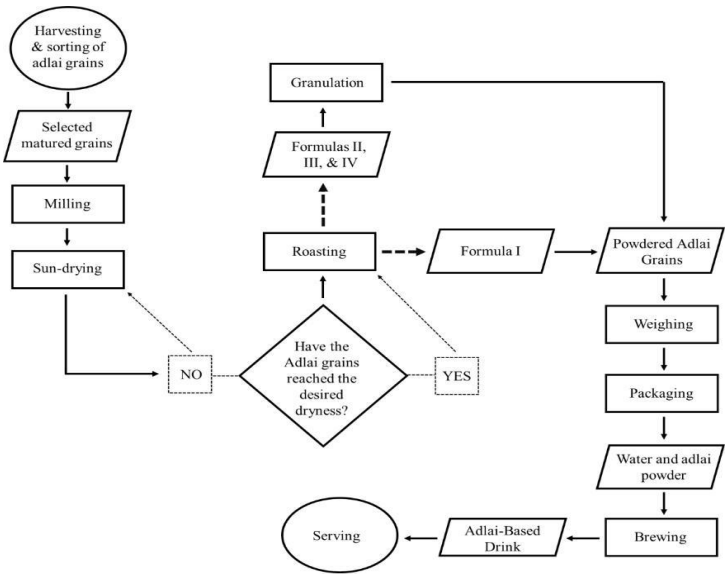

Figure 2. Flowchart of the Preparation and Formulation of Adlai-Based Drink

In the final stage, the Adlai powder is transformed into a consumable drink through brewing. This is done by mixing the measured powder with water using a consistent preparation method. The process ends with the Adlai-based drink ready for serving and evaluation.

Research Design

The study employs a comparative experimental research design, specifically utilizing a Completely Randomized Design (CRD), to examine the effect of roasting temperature on the quality of the Adlai-based drink. Experimental design refers to the structured planning of experiments in which treatments are assigned to experimental units in a controlled and organized manner (Curtis *et al*., 2022; Meta *et al*., 2026, as cited in Sokra, 2026). In this study, the design enables the researcher to determine how variations in roasting temperature influence the overall characteristics of the beverage while minimizing bias through random assignment.

The experiment consists of four different formulations. The control group, labeled as Formula I, uses non-granulated Adlai grains roasted at a baseline temperature of 100°C. This serves as the reference point for comparing the effects of the experimental treatments. Meanwhile, the experimental groups Formulas II, III, and IV undergo two main changes: the grains are granulated and roasted at increasing temperatures of 150°C, 200°C, and 250°C, respectively.

To ensure the validity and reliability of the results, several variables were kept constant throughout the experiment. As shown in Tables 1 and 3, all formulations were standardized in key aspects. Each treatment used 1000 grams of Adlai grains during production and 9 grams of powder per prepared cup. The roasting time was fixed at 40 minutes for all groups to ensure equal heat exposure. In addition, all samples followed the same "Farmer's Practice" method of preparation, using identical amounts of water (250 grams) and honey (42 grams).

Sensory Evaluation

Sensory evaluation was conducted to assess both the consumers' level of acceptability and the sensory profile of the Adlai-based beverage. The first step focused on determining consumer acceptability in order to identify which formulation was most preferred. The most acceptable formulation was then selected for further sensory profiling to gain a more detailed description of its characteristics, particularly in terms of appearance and color, aroma intensity, flavor profile, body or texture, and aftertaste.

The evaluation followed established principles of sensory science, with emphasis on accuracy, consistency, and sensitivity. It was guided by both affective and descriptive sensory analysis approaches as discussed by Meilgaard *et al.* (1991) and Stone and Sidel (1985). Sensory evaluation is a scientific method grounded in fields such as biology, chemistry, physics, and mathematics, and is commonly used in food science to better understand consumer perception and evaluate product quality.

Affective Sensory Evaluation

Affective sensory evaluation was conducted first to determine the level of consumers' acceptability of the developed Adlai-based beverage. A total of seventy-five (75) respondents participated in the study. Out of the total respondents, forty (40) came from Lanting Region National High School, composed of twenty (20) teachers (10 males and 10 females) and twenty (20) students randomly selected from Grade 7 to Grade 12. The remaining thirty-five (35) respondents were Bachelor of Technology and Livelihood Education (BTLED) – Home Economics students from Isabela State University Echague Campus. The respondents evaluated the drink based on sensory attributes such as appearance, aroma, flavor, and texture using a standardized hedonic scale. This evaluation was carried to determine the degree of liking and identify the most acceptable formulation to be used for the descriptive sensory evaluation. The scale used is presented in Table 4.

Scale	Range	Description
1	1.00 – 1.89	Dislike extremely
2	1.90 – 2.78	Dislike very much
3	2.79 – 3.67	Dislike moderately
4	3.68 – 4.56	Dislike slightly
5	4.57 – 5.44	Neither like nor dislike
6	5.45 – 6.33	Like slightly

7	6.34 – 7.22	Like moderately
8	7.23 – 8.11	Like very much
9	8.12 – 9.00	Like extremely

Table 4. 9-Hedonic Scale Used for the Affective Sensory Evaluation

Descriptive Sensory Evaluation

After identifying the most acceptable formulation, a descriptive sensory evaluation was conducted to further examine the sensory profile of the Adlai-based drink. This stage focused on a more detailed assessment of the product's characteristics, including appearance and color, aroma intensity, flavor profile, body or texture, and aftertaste. An evaluation instrument was used for this phase and was first subjected to validation by four licensed food technologists. It obtained a content validity index of ≥ 0.91, which is above the minimum acceptable threshold of ≥ 0.90. This indicates that the questionnaire achieved an excellent level of content validity after thorough evaluation and revision (See Appendix E for the sample questionnaire). For this part of the study, only twenty (20) respondents were involved as panelists. To ensure that they were suitable for sensory profiling, they underwent a screening and training process consisting of two tests: a taste identification test and a taste intensity test. Instruments were used for these tests which were both adapted from Ackbarali and Maharaj (2014) and researcher-made answer sheets were as well provided for the panelists. The first stage, taste identification, was conducted to determine whether the respondents could correctly recognize the basic tastes such as sweet, sour, salty, and bitter. For the actual taste solutions used in the panel's sensory training, standard taste solutions were adapted as shown in Table 5.

Basic Taste	Substance Used	Amount (g) per 250 mL Water (per solution)	Output
Sweet	Sugar	5 grams	Produces a sweet taste
Sour	Lemon extract	10 grams	Produces a sour taste
Salty	Salt (NaCl)	2.5 grams	Produces a salty taste
Bitter	Tonic water	5 grams	Produces a bitter taste

Table 5. Standard Taste Solutions Used for Taste identification Test of Panelist

Those who successfully passed were then subjected to the second stage, which was the taste intensity test. In this stage, panelists evaluated different concentrations of the basic taste solutions to assess their sensitivity and consistency in perception. Table 6 shows solution concentrations used.

Basic Taste	Substance Used	Solution Number	Amount (g) per 250 mL of Water
Sweet	Sugar	1	5 grams
		2	10 grams
		3	15 grams
Sour	Lemon extract	1	10 grams
		2	15 grams
		3	20 grams
Salty	Salt (NaCl)	1	2.5 grams
		2	5 grams
		3	7.5 grams
Bitter	Tonic water	1	5 grams
		2	10 grams
		3	15 grams

Table 6. Standard Taste Solutions Used for Taste Intensity Evaluation of Panelists

Appendix C presents the assigned taste for each trainee, where each participant was given only one basic taste to evaluate its intensity.

In particular, Bachelor of Technology and Livelihood Education (BTLED) students from Isabela State University – Echague Campus were intentionally selected for this phase due to their background in food preparation, product evaluation, and

sensory analysis. The BTLED students, numbering to 35, underwent the said initial screening process, while the other respondents participated only in the affective evaluation.

After the identification of the final twenty (20) respondents, the descriptive sensory evaluation proceeded using the validated questionnaire (See Appendix E). The adlai-based drink was assessed according to the following sensory attributes and evaluation criteria presented in Table 7. The validated questionnaires reviewed by the four food technologists included the 9-point hedonic scales used in the study. Each sensory attribute was matched with a corresponding linear scale for evaluation.

Sensory Attribute	Evaluation Criteria
Appearance and Color	Clarity, color intensity, and homogeneity
Aroma/Odor	Roasted aroma, grainy aroma, and overall aroma strength
Flavor/Taste	Roasted flavor and bitterness
Body/Texture	Smoothness
Aftertaste	Lingering taste

Table 7. Sensory Attributes and Evaluation Criteria of the Adlai-Based Beverage

Table 8 presents the 9-point linear scale tool used in evaluating the appearance and color of the developed Adlai-based drink. It specifically measures three key attributes: clarity, color intensity, and homogeneity.

Scale	Range	Description (Clarity)	Description (Color Intensity)	Description (Homogeneity)	Equivalent Interpretation
9	8.21 – 9.00	Very clear	Deep dark brown	Completely uniform	Excellent
8	7.41 – 8.20	Mostly clear	Dark brown	Very uniform	Very good
7	6.61 – 7.40	Slightly clear	Moderately dark brown	Mostly uniform	Good
6	5.81 – 6.60	Moderately clear	Medium dark brown	Slightly uneven	Moderately good
5	5.01 – 5.80	Fairly clear	Medium brown	Noticeably uneven	Fair
4	4.21 – 5.00	Slightly cloudy	Light-medium brown	Uneven	Slightly Poor
3	3.41 – 4.20	Cloudy	Light brown	Mostly uneven	Poor
2	2.61 – 3.40	Very cloudy	Very light brown	Very uneven	Very poor
1	1.00 – 2.60	Extremely cloudy	Lightest brown / almost colorless	Non-homogenous	Extremely Poor

Table 8. 9-Point Linear Scale Tool for Appearance and Color Assessment

Higher scale points indicate a clearer appearance, deeper brown color, and more uniform mixture, while lower scores reflect cloudiness, lighter color, and uneven consistency. The results are then interpreted using an equivalent descriptive rating ranging from "Excellent" to "Extremely Poor.

In addition, table 9 presents the 9-point linear scale used for the aroma evaluation of the Adlai-based drink. It assesses roasted aroma, grainy aroma, and overall aroma strength.

Scale	Range	Description (Roasted Aroma)	Description (Grainy Aroma)	Description (Over-All Aroma Strength)	Equivalent Interpretation
9	8.21 – 9.00	Strong	Strong	Intense; highly aromatic	Excellent

8	7.41 – 8.20	Very prominent	Very prominent	Very strong and bold	Very good
7	6.61 – 7.40	Clear, well-defined	Clear, natural grain	Strong and identifiable	Good
6	5.81 – 6.60	More than noticeable roasting	More than noticeable graininess	Moderately strong	Moderately good
5	5.01 – 5.80	Noticeable; moderate roasting	Noticeable; moderate graininess	Moderate strength; noticeable	Fair
4	4.21 – 5.00	Slightly detectable roasting	Slightly detectable graininess	Slightly weak	Slightly Poor
3	3.41 – 4.20	Barely present scent	Barely present scent	Weak and dull	Poor
2	2.61 – 3.40	Very faint	Very faint	Very weak	Very poor
1	1.00 – 2.60	Absent; no roasted scent	Absent; no roasted scent	Weak/No Aroma	Extremely Poor

Table 9. 9-Point Linear Scale for Aroma Assessment

Higher scores indicate a stronger, more distinct, and more pleasant aroma profile, while lower scores suggest weak or barely detectable aroma characteristics. Each rating is interpreted using a descriptive scale from "Excellent" to "Extremely Poor."

Furthermore, table 10 shows the 9-point linear scale used in evaluating the flavor profile of the Adlai-based drink. This includes the intensity of roasted flavor and the level of bitterness. Higher ratings reflect a stronger and more desirable flavor balance, while lower scores indicate weak, imbalanced, or undesirable taste characteristics. The results are interpreted using descriptive equivalents ranging from "Excellent" to "Extremely Poor."

Scale	**Range**	**Description (Roasted Flavor)**	**Description (Bitterness)**	**Equivalent Interpretation**
9	8.21 – 9.00	Very Strong	Very Strong	Excellent
8	7.41 – 8.20	Strong	Strong	Very good
7	6.61 – 7.40	Moderately Strong	Moderately Strong	Good
6	5.81 – 6.60	Noticeable	Slightly Above Balanced	Moderately good
5	5.01 – 5.80	Medium	Balanced	Fair
4	4.21 – 5.00	Mild	Mildly Weak	Slightly Poor
3	3.41 – 4.20	Slightly Weak	Weak	Poor
2	2.61 – 3.40	Very Weak	Very Weak	Very poor
1	1.00 – 2.60	Absent/Extremely Weak	Absent	Extremely Poor

Table 10. 9-Point Linear Scale for Flavor Assessment

Table 11 presents the 9-point linear scale used to assess the body or mouthfeel of the Adlai-based drink. It describes how full or light the beverage feels when consumed. Higher scores indicate a fuller-bodied and more satisfying texture, while lower scores reflect a lighter or watery consistency. The interpretation follows a scale from "Excellent" to "Extremely Poor." For the last attribute, table 12 shows the 9-point linear scale used for evaluating the aftertaste of the Adlai-based drink.

Scale	Range	Description (Roasted Flavor)	Equivalent Interpretation
9	8.21 – 9.00	Full-bodied	Excellent
8	7.41 – 8.20	Moderately full-bodied	Very good
7	6.61 – 7.40	Slightly full-bodied	Good
6	5.81 – 6.60	Slightly above medium bodied	Moderately good
5	5.01 – 5.80	Medium-bodied	Fair
4	4.21 – 5.00	Slightly below medium-bodied	Slightly Poor
3	3.41 – 4.20	Slightly light-bodied	Poor
2	2.61 – 3.40	Light-bodied	Very poor
1	1.00 – 2.60	Very light-bodied/watery	Extremely Poor

Table 11. 9-Point Linear Scale for Body Assessment

It measures how pleasant or unpleasant the lingering taste is after consumption. Higher ratings indicate a more pleasant and enjoyable aftertaste, while lower scores reflect an unpleasant or undesirable lingering sensation. The results are interpreted from "Excellent" to "Extremely Poor."

Scale	Range	Description (Aftertaste)	Equivalent Interpretation
9	8.21 – 9.00	Extremely pleasant	Excellent
8	7.41 – 8.20	Very pleasant	Very good
7	6.61 – 7.40	Moderately pleasant	Good
6	5.81 – 6.60	Slightly pleasant	Moderately good
5	5.01 – 5.80	Neutral aftertaste	Fair
4	4.21 – 5.00	Slightly unpleasant	Slightly Poor
3	3.41 – 4.20	Moderately unpleasant	Poor
2	2.61 – 3.40	Very unpleasant	Very poor
1	1.00 – 2.60	Extremely unpleasant	Extremely Poor

Table 12. 9-Point Linear Scale for Aftertaste Assessment

To reduce bias in both sensory evaluations, each formulation was given a code and presented to the panelists in a random order. Water was also provided so the respondents could cleanse their palate between samples to help them evaluate each formulation more accurately.

Cost and Return Analysis

A return analysis was conducted to determine the economic feasibility of the formulated products through the computation of return on investment (ROI), following the determination of the cost per formulation, assuming that the products would be sold in the market. The analysis was conducted by listing all costs incurred, from ingredients to material processing, including packaging, in producing the adlai-based drink. The unit cost and ROI per formulation were computed to evaluate profitability.
To carry out this analysis, the researcher followed the prescribed steps and formulas for determining the ROI of each formulation as presented in Figure 2.

The purpose of this is to inform the readers about the potential economic and financial benefits they could derive from processing and selling the adlai-based drink.

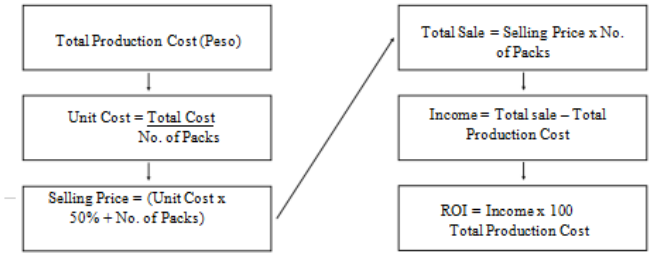

Figure 2. The Procedure to Determine Per Formulation's ROI

Statistical Analysis

To address the first objective, which is to evaluate the level of consumer acceptability and the sensory profile of the optimized and most acceptable formulation, the data gathered from the 9-point hedonic and linear scales were organized, tabulated, and summarized using descriptive statistics, particularly the mean. The results were then interpreted using established scale ranges to give a clear description of consumer preferences in terms of appearance, aroma, flavor, texture, and aftertaste.

To determine whether roasting temperatures had a significant effect on the sensory attributes among the four formulations, the data were analyzed using One-Way Analysis of Variance (ANOVA) under a Completely Randomized Design (CRD). All tests were carried out at a 5% level of significance ($\alpha = 0.05$). When significant differences were found, the Least Significant Difference (LSD) test was used as a post-hoc test for pairwise comparisons. This helped group the means and identify which formulations performed better, leading to the selection of the most acceptable formulation across the different roasting treatments.

Results and Discussion

Level of Consumer Acceptability of the Four Adlai-based Formulations

The study utilized a consistent ratio of 9 grams of Adlai to 250 milliliters of water, maintaining the "Farmers Practice" brewing tool and a 40-minute roasting time across all samples. The primary variable adjusted was the roasting temperature, which ranged from 100°F to 250°F. This adjustment is critical since sensory attributes were found to be significantly influenced by the roasting temperature and time (Fikry *et al*., 2019) to some other products intendedly as beverage. The data presented in Table 1 shows that Formulation I received the lowest scores across all attributes, resulting in a Grand Mean of 3.45. With a description of "Dislike Moderately," this version failed to meet consumer expectations, particularly in terms of appearance, which scored a low 2.39.

Attributes	Formulation I	Formulation II	Formulation III	Formulation IV
Appearance	2.39	4.47	8.11	8.47
Aroma	3.29	4.73	8.44	8.59
Flavor	3.91	5.60	8.37	7.49
Texture	3.55	5.00	8.12	7.72
Grand Mean	3.45	5.04	8.36	8.13
Description	DM	NLD	LE	LE

Legend: DM – Dislike Moderately; NLD – Neither Like nor Dislike; LE - Like Extremely

Given values are defined as follows: 1.00-1.89 Dislike Extremely; 1.90-2.78 Dislike Very Much; 2.79-3.67 Dislike Moderately; 3.68-4.56 Dislike Slightly; 4.57-5.44 Neither Like or Dislike; 5.45-6.33 Like Slightly; 6.34-7.22 Like Moderately; 7.23-8.11 Like Very Much; 8.12-9.00 Like Extremely.

Table 12. Level of Consumers' Acceptability of the Formulated Adlai-based Beverages

Table 12 shows the level of consumers' acceptability of the different formulations of the adlai-based beverage as evaluated in terms of appearance, aroma, flavor, and texture using the 9-point hedonic scale. The mean scores represent the respondents' degree of preference, while the descriptive ratings provide the corresponding interpretation of acceptability. The grand mean indicates the overall acceptability of each formulation, serving as the basis for determining the most preferred formulation. This suggests that the first prototype was not visually appealing to the participants and this is likely due to under-roasting. Consequently, similar to the findings of Masi et al. (2013), insufficient roasting may have resulted in a beverage with weak beverage-like characteristics, leading to lower consumer acceptance. Such outcome may be associated with under-roasting, which can limit the development of desirable color compounds typically produced during roasting and yet based from perusal, roasting significantly affects color of the roasted material, which typically changes from light brown to dark brown or nearly black depending on the roasting intensity (Asrad, 2023).

Formulation II showed progress, moving into the "Neither Like nor Dislike" category with a Grand Mean of 5.04. While its flavor and texture scores improved to 5.60 and 5.00 respectively, the overall reception remained neutral. At this stage, the beverage was considered acceptable but did not yet possess the sensory qualities needed to be highly recommended or preferred by consumers as it got a qualitative rating of "Neither like nor dislike." A breakthrough occurred with Formulation III, which achieved the highest overall rating with a Grand Mean of 8.36. This score falls under the "Like Extremely" descriptions. This formulation was particularly successful in the most critical sensory areas such as in flavor (8.37) and texture (8.12).

Formulation IV also performed very well, earning a "Like Extremely" rating with a Grand Mean of 8.13. Interestingly, this version received the highest scores for appearance (8.47) and aroma (8.59), meaning it was the most visually and aromatically pleasing. However, because its flavor and texture scores were slightly lower than those of Formulation III, it ranks as the second-best option. Both the Formulations III and IV are highly acceptable but Formulation III was being the top choice for product development.

Differences in the Consumers' Acceptability of the Adlai-Based Beverage According to Tested Attributes

Table 13 presents the sensory evaluation results regarding the appearance of the four developed Adlai-based beverage formulations. The analysis of variance (ANOVA) results reveal a highly significant difference among the formulations at the 5% level of significance. This suggests that variations in the formulation significantly influenced the visual preference of the consumers. According to Piqueras-Fiszman and Spence (2022), the color of a food or beverage provides consumers with important cues about its expected sensory properties, such as aroma, taste, freshness, and overall quality. These visual cues can also influence consumers' perception and hedonic response to a product. Formulation 4 obtained the highest mean score of 8.47, described as Like Extremely, followed by Formulation 3 with a mean of 8.11, described as Like Very Much. Based on the Least Significant Difference test, these two formulations share the same superscript "a," indicating no significant difference between them which marks them as the most visually acceptable to consumers. This suggests that the higher roasting temperatures used in these formulations successfully induced the Maillard reaction, producing the melanoidins responsible for the characteristic deep brown color of treated products (Starowicz & Zieliński, 2019).

FORMULATIONS	Mean	Description
Formulation 1	2.39^{c}	Dislike Very Much
Formulation 2	4.47^{b}	Dislike Slightly
Formulation 3	8.11^{a}	Like Very Much
Formulation 4	8.47^{a}	Like Extremely
ANOVA Result	**	
C.V. (%)	**20.87**	
LSD	**0.40**	

Note: Means with the same letter/s are not significantly different from each other using LSD test.
*** - significant at 5% level*
Given values are defined as follows: 1.00-1.89 Dislike Extremely; 1.90-2.78 Dislike Very Much; 2.79-3.67 Dislike Moderately; 3.68-4.56 Dislike Slightly; 4.57-5.44 Neither Like or Dislike; 5.45-6.33 Like Slightly; 6.34-7.22 Like Moderately; 7.23-8.11 Like Very Much; 8.12-9.00 Like Extremely.

Table 13. Significant Difference Among the Four Formulations of the Developed Adlai-Based Beverages in Terms of Appearance

In contrast, Formulations 1 and 2 were poorly received in terms of appearance. Formulation 2 recorded a mean score of 4.47, which is categorized as Dislike Slightly, while Formulation 1 received the lowest score of 2.39, categorized as Dislike Very Much. The distinct superscripts "b" and "c" for these formulations confirm that Formulation 1 is significantly less appealing than Formulation 2, and both are significantly lower in acceptability compared to Formulations 3 and 4. The Coefficient of Variation of 20.87% reflects the degree of variation in the scores provided by the respondents. The findings suggest that the physical characteristics or ingredient ratios used in Formulations 3 and 4 are highly effective in achieving a visually desirable product, whereas the appearance of Formulations 1 and 2 failed to meet consumer expectations.

Table 14 presents the sensory evaluation results regarding the aroma of the four developed Adlai-based beverage formulations. The analysis of variance results indicate a highly significant difference among the formulations at the 5% level of significance, suggesting that the aromatic profiles were significantly influenced by the specific formulations. Formulation 4 obtained the highest mean score of 8.59, followed closely by Formulation 3 with a mean of 8.44; both are described as Like Extremely. Several previous studies emphasize the significant role of roasting in developing desirable aroma characteristics. For instance, research on cacao processing by Ac-Pangan (2021) reported that roasted chocolate exhibited a stronger roasted aroma compared to unroasted samples. In addition, Lu *et al*., (2023) showed that heavy roasting increased aroma compounds like aldehydes, ketones, furans, and pyrazines. These related findings support the present result, suggesting that the higher roasting level of Formulation 3 and 4 likely enhanced the formation of aroma compounds which made them more appealing to consumers.

According to the Least Significant Difference test, these two formulations share the same superscript "a," indicating no significant difference between them and establishing them as the most aromatically appealing options to consumers. In contrast, Formulations 1 and 2 received notably lower scores for aroma. Formulation 2 recorded a mean score of 4.73, categorized as Neither Like nor Dislike, while Formulation 1 received a mean of 3.29, categorized as Dislike Moderately. The distinct superscripts "b" and "c" for these formulations confirm that Formulation 1 is significantly less appealing than Formulation 2, and both are significantly lower in acceptability compared to Formulations 3 and 4. The Coefficient of Variation of 23.01% gives the degree of differences in the panels' scores. The findings imply that the aromatic characteristics of Formulations 3 and 4 are highly successful, whereas the aroma of Formulations 1 and 2 failed to gain positive consumer interest.

FORMULATIONS	Mean	Description
Formulation 1	3.29^{c}	Dislike Moderately
Formulation 2	4.73^{b}	Neither Like nor Dislike
Formulation 3	8.44^{a}	Like Extremely
Formulation 4	8.59^{a}	Like Extremely
ANOVA Result	**	
C.V. (%)	**23.01**	
LSD	**0.45**	

Note: Means with the same letter/s are not significantly different from each other using LSD test.
*** - significant at 5% level*
Given values are defined as follows: 1.00-1.89 Dislike Extremely; 1.90-2.78 Dislike Very Much; 2.79-3.67 Dislike Moderately; 3.68-4.56 Dislike Slightly; 4.57-5.44 Neither Like or Dislike; 5.45-6.33 Like Slightly; 6.34-7.22 Like Moderately; 7.23-8.11 Like Very Much; 8.12-9.00 Like Extremely.

Table 14. Significant Difference Among the Four Formulations of the Developed Adlai- Based Beverages in Terms of Aroma

Table 15 presents the sensory evaluation results regarding the texture of the four developed Adlai-based beverage formulations. The analysis of variance results display a highly significant difference among the formulations at the 5% level of significance, suggesting that the variations in the recipe significantly influenced the mouthfeel and consistency of the beverage. Formulation 3 obtained the highest mean score of 8.12, described as Like Extremely, followed by Formulation 4 with a mean of 7.72, described as Like Very Much. Based on the Least Significant Difference test, these two formulations share the same superscript "a," indicating no significant difference between them, which marks them as the most texturally acceptable options to consumers. In contrast, Formulations 1 and 2 were significantly less appealing in terms of texture. Formulation 2 recorded a mean score of 5.00, categorized as Neither Like nor Dislike, while Formulation 1 received a mean of 3.55, categorized as Dislike Moderately. The distinct superscripts "b" and "c" for these formulations confirm that Formulation 1 is significantly less desirable than Formulation 2, and both are significantly lower in acceptability compared to Formulations 3 and 4

FORMULATIONS	Mean	Description
Formulation 1	3.55[c]	Dislike Moderately
Formulation 2	5.00[b]	Neither Like nor Dislike
Formulation 3	8.12[a]	Like Extremely
Formulation 4	7.72[a]	Like Very Much
ANOVA Result	**	
C.V. (%)	**30.53**	
LSD	**0.59**	

Note: Means with the same letter/s are not significantly different from each other using LSD test.
*** - significant at 5% level*
Given values are defined as follows: 1.00-1.89 Dislike Extremely; 1.90-2.78 Dislike Very Much; 2.79-3.67 Dislike Moderately; 3.68-4.56 Dislike Slightly; 4.57-5.44 Neither Like or Dislike; 5.45-6.33 Like Slightly; 6.34-7.22 Like Moderately; 7.23-8.11 Like Very Much; 8.12-9.00 Like Extremely.

Table 15. Significant Difference Among the Four Formulations of the Developed Adlai-Based Beverages in Terms of Texture

The Coefficient of Variation of 30.53% reflects a degree of variation in the respondents' scores. The observed differences in texture acceptability of the Adlai-based beverages may be attributed to the impact of roasting on starch. To note, the starchy endosperm of the Adlai grain constitutes the largest structural component of most grains, with starch making up about 80% of it (Evers *et al*., 1999). According to Zhao *et al.* (2020), roasting slightly decreases starch solubility and swelling in grains, which helps maintain some granule structure during brewing. This controlled change in starch properties can enhance the texture, which likely explains why Formulations 3 and 4, roasted at higher temperatures, were rated more favorably in texture than the under-roasted Formulations 1 and 2.

Table 15 presents the sensory evaluation results regarding the flavor of the four developed Adlai-based beverage formulations. The analysis of variance results present a highly significant difference among the formulations at the 5% level of significance, suggesting that the variations in the recipe significantly altered the taste profile and consumer preference. Formulation 3 obtained the highest mean score of 8.37, described as Like Extremely, followed by Formulation 4 with a mean of 7.49, described as Like Very Much. Notably, the Least Significant Difference test assigned unique superscripts to these two formulations, "a" and "b" respectively, confirming that Formulation 3 is significantly superior to Formulation 4 in terms of flavor.

FORMULATIONS	Mean	Description
Formulation 1	3.91[d]	Dislike Slightly
Formulation 2	5.60[c]	Like Slightly
Formulation 3	8.37[a]	Like Extremely
Formulation 4	7.49[b]	Like Very Much
ANOVA Result	**	
C.V. (%)	**29.79**	
LSD	**0.59**	

Note: Means with the same letter/s are not significantly different from each other using LSD test.
*** - significant at 5% level*
Given values are defined as follows: 1.00-1.89 Dislike Extremely; 1.90-2.78 Dislike Very Much; 2.79-3.67 Dislike Moderately; 3.68-4.56 Dislike Slightly; 4.57-5.44 Neither Like or Dislike; 5.45-6.33 Like Slightly; 6.34-7.22 Like Moderately; 7.23-8.11 Like Very Much; 8.12-9.00 Like Extremely.

Table 16. Significant Difference Among the Four Formulations of the Developed Adlai Based Beverages in Terms of Flavor

In contrast, Formulations 1 and 2 received the lowest scores for flavor. Formulation 2 recorded a mean of 5.60, categorized as Like Slightly, while Formulation 1 received a mean of 3.91, categorized as Dislike Slightly. The superscripts "c" and "d" for these formulations indicate that Formulation 1 is significantly less palatable than Formulation 2, and both are significantly less acceptable than Formulations 3 and 4. The Coefficient of Variation of 29.79% signifies a higher degree of variation in respondent scores compared to other attributes. Seninde and Chambers (2020) confirmed that dark roasted beans or grains produced brews that had higher intensities for flavor attributes such as sweet aromatics as compared to

corresponding medium roasted grain. The findings establish Formulation 3 as the most liking in terms of flavor, outperforming all other formulations.

Most Acceptable Adlai-Based Beverage Formula

Table 17 presents the general acceptability of the four developed Adlai-based beverage formulations, calculated from the combined sensory attributes. Among the formulations, Formulation 3 emerged as the most preferred formula since it achieved the highest mean score of 8.36. This is followed by Formulation 4 with a score of 8.13. Both scores fall within the highly favorable range of consumer acceptance implying that higher roasting temperatures produces a more desirable product.

Formulation	General Acceptability Mean
I - 100°C, 40 minutes	3.45
II – 150°C, 40 minutes	5.04
III – 200°C, 40 minutes	8.36
IV – 250°C, 40 minutes	8.13

Table 17. Most Acceptable Formula Based on the Computed General Acceptability

The superior performance of Formulation 3 and Formulation 4 indicates that a roasting temperature of 200°C to 250°C is the optimal range for enhancing the sensory qualities of Adlai as processed beverage. Specifically, the peak acceptability at 200°C (Formulation 3) suggests that this temperature provides the most balanced development of flavor, aroma, texture and appearance. When the temperature was increased to 250°C (Formulation 4), the score slightly decreased, which may imply that exceeding 200°C begins to introduce a charred profile that some consumers find less appealing.

In contrast, Formulation 1 (100°C) and Formulation 2 (150°C) were notably less acceptable, with mean scores of 3.45 and 5.04, respectively. These results demonstrate that lower roasting temperatures are insufficient for developing the characteristic of sensory profile expected of an Adlai-based beverage. In particular, Formulation 1, which utilized the lowest temperature and lacked granulation, failed to meet consumer expectations significantly. The data reveals that as the roasting temperature increased toward 200°C, consumer acceptability improved. That is why Formulation 3 was the most acceptable for production.

Sensory Profile of the Most Acceptable Adlai-Based Beverage Formulation

Tables 13 to 17 present the sensory profile of the most acceptable adlai-based beverage formulation as evaluated by the panelists. The sensory characteristics of the beverage were assessed in terms of appearance and color, aroma intensity, flavor, body, and aftertaste using a 9-point hedonic or linear scale. These attributes were examined to determine the overall sensory quality and consumer acceptability of the selected adlai-based beverage formulation which was identified as the most acceptable during Phase I of the consumer acceptability test.

Appearance and Color Profile Assessment

The appearance and color of the adlai-based beverage were evaluated in terms of clarity, color intensity, and homogeneity using a horizontal nine-point hedonic scale. According to the data presented in Table 1, the beverage received an overall assessment mean of 6.2, which corresponds to a “Moderately Good” rating on the 9-point hedonic scale.

Among the specific criteria, homogeneity received the highest score of 6.65, described as “mostly uniform” and interpreted as “good.” This indicates that the beverage maintained a consistent appearance throughout the serving with a notable absence of floating grains or unsightly sediments which suggest an effective stabilization or filtration process during production. Actually, the ideal beverage product should have a homogeneous appearance (Marin & Gonzales, 2022) and there is a need to achieve the desired homogeneity because as noted by Sethi *et al.* (2016), consumers associate high homogeneity with professional processing and safety.

Criteria	Mean	Description	Equivalent Interpretation
Clarity The beverage appears clear and transparent, with no visible cloudiness or suspended particles.	5.8	Fairly clear	Fair

Color intensity The beverage exhibits a color depth and richness that ranges from light to dark brown.	6.15	Medium dark brown	Moderately good
Homogeneity The beverage has a consistent appearance throughout the cup, with no floating grains, sediments, or uneven color.	6.65	Mostly uniform	Good
Over-All Assessment Result	**6.2**	**Moderately Good**	

Table 18. Appearance and Color Profile of the Adlai-Based Beverage

Color intensity followed with a mean of 6.15, characterized as "medium dark brown" and interpreted as "moderately good." This suggests that the processing of the adlai grains successfully imparted a rich hue that matches what consumers expect from grain-based drinks. The "medium dark brown" intensity observed in the beverage is likely a result of thermal processing. Research indicates that the roasting or heat formulation of grains initiates the Maillard reaction, where the interaction between amino acids and reducing sugars produces melanoidins that darken the product (Yu *et al*., 2025). While, clarity received the lowest score among the three attributes at 5.8, interpreted as "fairly clear" or "fair" which indicates there were a few tiny particles or a slight cloudiness. Achieving high clarity in grain-based drinks remains a challenge as the protein content of adlai is remarkably high, especially in the seed kernels, which contain about 20% (Weng *et al*., 2022) and this contribute to cloudiness.

Aroma Intensity Profile Assessment

The olfactory characteristics of the adlai-based beverage were evaluated to determine the impact of its aromatic components on overall product quality. Based on the data in Table 2, the beverage achieved an Over-all Assessment Result of 8.02, which corresponds to a "Very Good" rating. This high score suggests that the aromatic profile is one of the most successful sensory attributes of the product. These results are consistent with the findings of Torre (2018), who observed that adlai-based functional beverages frequently exhibit a high degree of olfactory appeal.

The grainy aroma emerged as the strongest individual attribute with a mean of 8.35, described as "Strong" and interpreted as "Excellent." This indicates that the natural, quintessential scent of the adlai grain was successfully preserved. To note, adlai grains have aldehydes such as the vanillic acid (Weng, 2022). Within the aroma profile, aldehydes serve as the primary volatile odorants responsible for the foundational "grain aroma" (Yuan *et al*., 2025) of grain-based beverages. The signature "grainy" character remains a defining feature of the final beverage as revealed by the computed mean of 8.35.

Criteria	Mean	Description	Equivalent Interpretation
Roasted Aroma The beverage has a roasted scent, featuring warm, nutty, and toasted characteristics.	7.65	Very prominent	Very good
Grainy Aroma The beverage releases a characteristic grainy aroma, typical of cooked or toasted Adlai grains.	8.35	Strong	Excellent
Over-all Aroma Strength The beverage has a noticeable aroma with overall intensity when smelled.	8.05	Very strong and bold	Very good
Over-All Assessment Result	**8.02**	**Very good**	

Table 19. Aroma Intensity Profile of the Adlai-Based Beverage

The roasted aroma and overall aroma strength followed closely with means of 7.65 ("Very prominent") and 8.05 ("Very strong and bold"), respectively, both falling under a "Very Good" interpretation. The development of these warm, nutty, and toasted characteristics is directly linked to the Maillard reaction (MR), a natural process for improving the flavor in various model systems and food products (Liu *et al*., 2022). MR is largely responsible for the development of color, taste, and especially aroma of thermally treated food (Starowicz & Zielinski, 2019). The data suggests the roasting phase was well-controlled. This developed a deeper aromatic profile while still allowing the grain's original character to come through. These two attributes directly inform the Overall Aroma Strength, which received a high mean score of 8.05 (Very Strong and Bold/Very Good).

Flavor Profile Assessment

The flavor profile of the adlai-based beverage was evaluated using a 9-point hedonic scale, focusing on roasted flavor and bitterness, as presented in Table 3. The results reveal that the beverage obtained an overall mean score of 8.53, which falls within the range of 8.21–9.00, interpreted as "Excellent." This indicates that the beverage possessed desirable flavor characteristic as perceived by the panelists.

Criteria	Mean	Description	Equivalent Interpretation
Roasted Flavor The beverage has a strong roasted flavor that can be clearly perceived during tasting.	8.55	Very Strong	Excellent
Bitterness The beverage has a certain degree of bitterness that is typically present in adlai-based beverage.	8.50	Very Strong	Excellent
Over-All Assessment Result	**8.53**	**Excellent**	

Table 20. Flavor Profile of the Adlai-Based Beverage

The very strong roasted flavor of the adlai-based beverage, with a mean score of 8.55, is attributed to chemical reactions that occur during roasting. According to Farah (2019), the Maillard reaction and caramelization are responsible for developing the characteristic color, aroma, especially the flavor of roasted grains. These reactions involve carbohydrates, which serve as important precursors. Since adlai contains about 73.9 grams of carbohydrates (Client Challenge, n.d.), the roasting process likely promoted these reactions, resulting in the pronounced roasted flavor perceived by the panelists.

In contrast, a study on the sensory acceptance of sorghum-adlai-based milk by Sanjaya and Romulo (2023) reported that the addition of adlai decreased the product's likeness among panelists. This was attributed to adlai's high concentration of phenolic compounds, particularly ferulic acid and tannins, which are known to contribute to bitter flavors (Sanjaya & Romulo, 2023). However, despite the natural bitterness associated with adlai, the results of the present study show that the bitterness level of the beverage remained acceptable and well-perceived, as reflected in the high mean score of 8.50.

The findings suggest that the adlai-based beverage exhibited a well-developed flavor profile, where both roasted flavor and bitterness were strongly perceived and appreciated by the evaluators. The high overall assessment score of 8.53 indicates that the beverage was highly acceptable in terms of flavor. As mentioned by Wolinska-Kennard *et al.*, (2025), flavor is a key factor in consumer satisfaction and food acceptance, as it is influenced by the combined perception of taste, aroma, and mouthfeel. Given that the adlai-based beverage was evaluated as having excellent flavor, it is likely that other sensory attributes, such as aroma and body, were also perceived positively. It is believed to contribute to the overall positive acceptance of the product.

Body Profile Assessment

Body is a key sensory characteristic for beverage acceptability, drinkability and an important consideration when making a purchase decision (Ivanova *et al.,* 2022). The body assessment of the Adlai-based beverage yielded a mean score of 6.45, which directly corresponds to the 5.81 – 6.60 range on the 9-point linear scale. This identifies the drink as "Slightly above medium-bodied" with a qualitative interpretation of "Moderately good." This score indicates that the beverage has moved beyond a "Medium-bodied" (5.01 – 5.80) profile but has not quite reached the "Slightly full-bodied" (6.61 – 7.40) status. Data is presented in Table 21.

Criteria	Mean	Description	Equivalent Interpretation
Texture/Mouthfeel The beverage has a soft, fine, and gently textured mouthfeel.	6.45	Slightly above medium bodied	Moderately good
Over-All Assessment Result	**6.45**	**Moderately good**	

Table 21. Body Profile of the Adlai-Based Beverage

The body profile of the adlai-based beverage can be linked to the natural starch composition of Adlai (Coix lacryma-jobi L.). Adlai, also known as Job's tears, is an underutilized cereal crop in the Philippines that shows great potential as a source of

starch (Capule & Trinidad, 2016). One key component of starch, amylopectin (Wikipedia Contributors, 2025), contributes to a naturally viscous and smooth mouthfeel when the grain is processed into a liquid. This characteristic helps explain why the adlai-based beverage received a score on the upper end of the medium-bodied scale (6.45), as the gelatinized starches give it a pleasant "weight" on the palate which made the drinking experience more satisfying for the panelists.

Aftertaste Profile Assessment

The aftertaste profile of the adlai-based beverage obtained a mean score of 6.90, which corresponds to "Moderately Pleasant" with an equivalent interpretation of "Good" based on the 9-point linear scale. This indicates that the sensory panel generally perceived the lingering taste of the beverage as favorable, even though a noticeable grainy flavor remained in the mouth after consumption.

Falling within the 6.61–7.40 range, the score suggests a good level of consumer acceptance, indicating that the aftertaste did not negatively affect the overall drinking experience.

Criteria	Mean	Description	Equivalent Interpretation
Aftertaste The beverage leaves a noticeable grainy flavor that lingers in the mouth even after swallowing.	6.90	Moderately pleasant	Good
Over-All Assessment Result	**6.90**	**Good**	

Table 22. Aftertaste Profile of the Adlai-Based Beverage

It is important to note that limited studies are available regarding the specific aftertaste characteristics of adlai-based products. This makes direct comparisons with existing literature challenging. However, the present findings suggest that the aftertaste of the beverage remains generally acceptable to consumers, indicating that the formulation and processing of the adlai beverage were able to maintain a pleasant sensory experience despite the inherent grain flavor.

Developed IEC Material of the Most Acceptable

Formula for Adlai-Based Beverage

The provided IEC material in Figure 1 is a five-panel informational brochure designed to promote the developed Adlai-based beverage as a healthy, sustainable, and local alternative to traditional coffee.

The material identifies the product as an "Adlai-Based Beverage," positioned as a nutty, caffeine-free alternative to coffee. It highlights four primary value propositions: it is gluten-free, rich in nutrients, supports local farmers, and is made from a climate-resilient crop. The overall theme centers on promoting food security and sustainable agriculture in the Philippines. The brochure defines Adlai (*Coix lacryma-jobi L.),* also known as "Job's Tears," as a nutritious grain grown in the Philippines and Southeast Asia. It describes the grain as a "functional food" and lists its nutritional value, noting that it is high in dietary

fiber, rich in protein, contains essential minerals like calcium, iron, and phosphorus, and is naturally gluten-free (Sangalang *et al*., 2023; Andoy *et al*., 2019).

A specific section is dedicated to the health-boosting properties of the drink. It mentions the presence of important phytochemicals, specifically phenolic compounds and flavonoids (Gbokwe *et al.,* 2021). These are credited with providing antioxidant effects, supporting the immune system, reducing oxidative stress, and promoting healthy digestion. A key distinction made is that, unlike coffee, this beverage is naturally caffeine-free as Adlai belongs to the Poaceae family or grasses (Magallon & Cabahug, 2022) and plants within this family are not known to naturally produce caffeine.

The material gives a five-step process for creating the beverage: harvesting mature grains, sun-drying, roasting to enhance flavor, grinding into powder, and finally brewing with hot water. It also offers a serving suggestion, noting that honey can be added for optional natural sweetness.

The final panel serves as a call to action to "Support Local Farmers." It explains that consuming Adlai promotes healthy lifestyles, encourages agricultural innovation, strengthens community livelihoods, and supports food innovation.
Cost and Return Analysis for the Formulated Adlai-Based Beverages

Table 6 presents the calculated production costs for the four formulated adlai-based beverages. The results show that the ingredient costs were the same across all formulations. Each formulation required ₱125.00 worth of water and ₱192.00 worth of roasted adlai powder, resulting in a subtotal of ₱387.00 for ingredients. This indicates that the primary raw materials used in the beverage formulations remained constant regardless of the variation in formulation.

Particulars	Formulation I	Formulation II	Formulation III	Formulation IV
Ingredients				
1. Water	₱ 125.00	₱ 125.00	₱ 125.00	₱ 125.00
2. Roasted Adlai Powder	₱ 192.00	₱ 192.00	₱ 192.00	₱ 192.00
Sub-Total	₱ 387.00	₱ 387.00	₱ 387.00	₱ 387.00
Operating Expenses				
1. Packaging Material (Plastic Bottles)	₱ 500.00	₱ 500.00	₱ 500.00	₱ 500.00
2. Grinding Service	₱ 0.00	₱ 100.00	₱ 100.00	₱ 100.00
3. Gas	₱ 145.00	₱ 150.00	₱ 155.00	₱ 160.00
Sub-Total	₱ 645.00	₱ 750.00	₱ 755.00	₱ 760.00
Total Cost	**₱ 1, 032.00**	**₱ 1, 137.00**	**₱ 1, 142.00**	**₱ 1, 147.00**

Table 23. Calculated Production Costs for the Four Formulated Adlai-Based Beverages

However, differences in the total production cost were mainly influenced by the operating expenses. The cost of packaging materials, specifically plastic bottles, was consistent for all formulations at ₱500.00. In contrast, the grinding service cost varied, with Formulation I incurring no grinding cost, while Formulations II, III, and IV each required ₱100.00 for grinding services. Additionally, the cost of gas slightly increased across the formulations due to the required roasting temperature for each formulation, with Formulation I costing ₱145.00, Formulation II at ₱150.00, Formulation III at ₱155.00, and Formulation IV at ₱160.00. As a result, the subtotal for operating expenses ranged from ₱645.00 for Formulation I to ₱760.00 for Formulation IV.

The overall production cost was lowest for Formulation I at ₱1,032.00, followed by Formulation II at ₱1,137.00, Formulation III at ₱1,142.00, and Formulation IV at ₱1,147.00. The gradual increase in total cost among the formulations can be attributed primarily to the additional grinding service and the slight rise in gas expenses. These findings suggest that even if the ingredient costs remained stable, variations in operating expenses significantly influenced the overall production cost of the adlai-based beverages. In terms of the estimated return-on-investment (ROI), the results show that all formulations generated positive returns indicating that the production of the adlai-based beverage can be considered economically viable. Among the four formulations, Formulation I recorded the lowest total production cost at ₱1,032.00, resulting in a unit cost of ₱20.64 per pack. When sold at a computed selling price of ₱60.32 per pack, the total sales reached

₱3,016.00, generating an income of ₱1,984.00. Formulation I achieved the highest return on investment (ROI) of 192.24%, suggesting that it is the most profitable

In contrast, Formulation II, Formulation III, and Formulation IV had slightly higher production costs amounting to ₱1,137.00, ₱1,142.00, and ₱1,147.00, respectively. Their corresponding unit costs ranged from ₱22.74 to ₱22.94 per pack, which led to slightly higher selling prices between ₱61.37 and ₱61.47. Despite generating comparable total sales of ₱3,068.00, ₱3,071.00, and ₱3,073.50, the higher production costs resulted in slightly lower incomes and returns. The computed ROI values were 169.87% for Formulation II, 168.91% for Formulation III, and 167.95% for Formulation IV. among the four formulations.

Formula	Formulation I	Formulation II	Formulation III	Formulation IV
Total Production Cost (Php)	₱ 1, 032.00	₱ 1, 137.00	₱ 1, 142.00	₱ 1, 147.00
Unit Cost = Total Production Cost / No. Of Packs	₱ 20.64	₱ 22.74	₱ 22.84	₱ 22.94
Selling Price = (Unit Cost x 50% +No. Of Packs)	₱ 60.32	₱ 61.37	₱ 61.42	₱ 61.47
Total Sale = Selling Price x No. Of Packs	₱ 3, 016.00	₱ 3, 068.00	₱ 3, 071.00	₱ 3, 073.50
Income = Total Sale - Total Production Cost	₱ 1, 984.00	₱ 1, 931.50	₱ 1, 921.50	₱ 1, 926.50
ROI = Income x100 / Total Production Cost	192.24%	169.87%	168.91%	167.95%

Table 24 Estimated Returns for the Four Formulated Adlai-Based Beverages

As all four formulations demonstrated profitability with ROI values exceeding 100%, the results indicate that Formulation I provides the highest return due to its lower production cost while still generating substantial sales. This suggests that Formulation I may be the most advantageous option for potential production and commercialization of the adlai-based beverage.

Conclusion and Recommendations

The study concluded that roasting temperature significantly influences the sensory acceptability of an adlai-based beverage. The formulation roasted at 200°C was identified as the most acceptable.
The findings contribute to product standardization and support the development of adlai as a functional, caffeine-free beverage alternative.

Implications

- Provides basis for **product development and commercialization**
- Supports **local farmers and sustainable agriculture**
- Promotes **health-conscious beverage alternatives**

Limitations

- Limited to sensory evaluation and selected variables
- Results may vary with different processing techniques

Recommendations

- Further studies on shelf life and nutritional analysis
- Expansion to larger consumer groups
- Exploration of other formulations and flavor variations

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Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study; all data used were obtained from previously published sources as cited in the reference list.

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Appendices

No appendices are attached to this study.