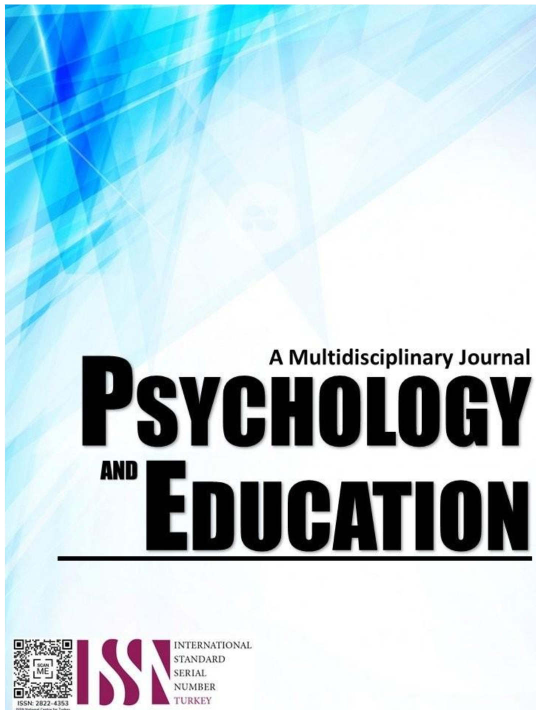
ACCEPTABILITY OF SAGO PALM (METROXYLON SAGU) AND RICE FLOUR NOODLES: DEVELOPMENT OF A PRODUCTION TECHNO-GUIDE FOR THE PHILIPPINES



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Acceptability of Sago Palm (Metroxylon Sagu) and Rice Flour Noodles: Development of a Production Techno-Guide for the Philippines

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Abstract

Sago palm (Metroxylon sagu) has gained attention as a potential wheat flour alternative due to its local availability and functional properties; however, its application in noodle products requires systematic sensory evaluation and formulation optimization. This study aimed to evaluate the consumer acceptability of sago palm–rice flour noodles as a basis for developing a production techno-guide. An experimental research design was employed using four noodle formulations with varying sago palm and rice flour ratios. Sensory evaluation was conducted by a total of n = 110 panelists, composed of trained and untrained evaluators, using a 9-point Hedonic Scale to assess color, aroma, texture, flavor, and overall acceptability. Data were analyzed using analysis of variance (ANOVA) to determine significant differences among treatments. Results showed that Treatment 1 (80 g sago palm: 20 g rice flour) obtained the highest acceptability ratings, with mean scores of M = 4.30 (trained panelists) and M = 4.46 (untrained panelists). All sensory attributes exhibited statistically significant differences among treatments ($p < 0.05$). Treatment 1 also demonstrated favorable production economics, with a cost of 16.42 Pesos per 100 g batch. Overall, the findings indicate that sago palm–rice flour noodles with optimized formulation ratios are sensory acceptable and economically viable, providing a strong empirical basis for the development of a production techno-guide.

Keywords: *sago palm, wheat flour alternative, product formulation, sensory evaluation, consumer acceptability, techno-guide*

Introduction

Noodles are a significant and widely consumed food in the Filipino diet, spanning generations and regions, and are commonly served in both everyday meals and special occasions (Bugtai et al., 2024). Beyond their convenience and palatability, noodles hold cultural and social value, frequently appearing in family gatherings, community celebrations, and festive events. Their popularity continues to grow alongside urbanization, changing lifestyles, and increased demand for convenient and ready-to-eat foods.

Despite strong domestic demand, the Philippine noodle industry remains heavily dependent on imported wheat flour, as wheat is not locally produced at a commercial scale. According to the Philippine Statistics Authority (2020), nearly 100% of the country's wheat requirements are imported, exposing local food manufacturers to international price volatility, rising transportation costs, and supply chain disruptions. The Department of Trade and Industry (2022) reported that fluctuations in global wheat prices have significantly affected production costs, placing pressure on small- and medium-scale food enterprises and increasing retail prices for consumers. This import dependence constrains the utilization of local agricultural resources and poses risks to national food security, particularly during global market shocks.

In response to these challenges, there is a growing need to explore locally available, sustainable alternatives to wheat flour. One promising option is sago palm (Metroxylon sagu), a starch-rich crop commonly found in marshy and marginal areas of Southeast Asia, including parts of the Philippines (Arifin, Rahman, & Putri, 2024). Sago palm is valued for its high starch yield, adaptability to low-input environments, and potential for diverse food applications. However, despite these advantages, sago remains underutilized in modern food systems and is rarely incorporated into value-added products such as noodles. While previous studies have examined the physicochemical properties of sago starch and its blending behavior with other flours, critical gaps remain in understanding consumer acceptability across varying formulation ratios and in translating laboratory findings into practical production guides.

Addressing this gap requires moving beyond technical feasibility toward consumer-centered evaluation. Consumer acceptability is a decisive factor in determining whether alternative food products can succeed in the market. Research consistently shows that sensory attributes—such as taste, texture, appearance, and aroma—strongly influence consumer preference and purchasing behavior (Gómez-Corona, Escalona-Buendía, & Yepez-García, 2024). Products that meet functional or nutritional standards may still fail commercially if they do not align with consumer sensory expectations. Thus, systematic sensory evaluation is essential to link formulation characteristics with consumer preference and guide product optimization.

In addition to sensory validation, the successful adoption of alternative noodle products in the Philippines depends on practical implementation, particularly among small and medium enterprises (SMEs). Many local food producers face barriers such as the absence of standardized processing protocols, limited quality control guidelines, and insufficient technical expertise in product formulation and scaling. To address these constraints, this study develops a techno-guide that integrates sensory evaluation results with practical considerations in formulation, processing, and cost efficiency (Garcia & Campos, 2022). This techno-guide serves as a structured reference for food technologists, entrepreneurs, and researchers, bridging the gap between research and industry application and supporting innovation using underutilized local resources (Torres et al., 2019).

By evaluating the sensory acceptability of sago palm–based noodles across formulation ratios and developing a production techno-guide, this study responds to key challenges in the Philippine food industry. It contributes to efforts to reduce dependence on imported wheat flour, promote local agricultural resources, and support sustainable food systems, while ensuring that product innovation aligns with consumer preferences and industry needs.

Research Objectives

This study determined the consumer acceptability of sago palm noodles at Cebu Technological University- Barili Campus for the school year 2025-2026 as a basis for developing a techno-guide. Specifically, this study sought to answer the following sub-questions:

1. To formulate four sago palm noodle treatments with varying sago palm–rice flour ratios, namely:
   1.1. Treatment 1 (T1): 80 g sago palm: 20 g rice flour with standard ingredients;
   1.2. Treatment 2 (T2): 60 g sago palm: 40 g rice flour with standard ingredients;
   1.3. Treatment 3 (T3): 40 g sago palm: 60 g rice flour with standard ingredients; and
   1.4. Treatment 4 (T4): 20 g sago palm: 80 g rice flour with standard ingredients?
2. To evaluate the sensory attributes of the developed sago palm noodles, specifically color, aroma, taste, texture, and general acceptability, using trained and untrained panelists through standardized sensory evaluation instruments.
3. To determine whether significant differences exist among the four noodle formulations in terms of color, aroma, taste, texture, and general acceptability using analysis of variance (ANOVA).
4. To identify the most acceptable sago palm noodle formulation based on sensory evaluation scores and cost-effectiveness analysis.
5. To develop a comprehensive production techno-guide based on the optimal formulation and sensory evaluation findings.

Literature Review

Historical Context of Sago-Based Foods

Traditional Filipino food systems reflect long-standing cultural interactions and adaptive use of locally available resources. Sidiq et al. (2021) emphasized that many indigenous food products evolved through historical exchanges within Southeast Asia, particularly with Indonesian and Melanesian societies, where sago is a dietary staple. Although the precise origins of sago noodle production are undocumented, sago starch has been used for centuries in various Filipino communities as a primary carbohydrate source. Early sago-based foods relied on simple processing techniques and minimal ingredients, reflecting subsistence-oriented culinary practices. Contemporary sago noodle production applies more standardized processing methods—such as starch extraction, binding, and strand formation—while retaining traditional principles of adaptability and resource efficiency. However, most historical accounts focus on cultural relevance rather than product standardization, leaving gaps in the systematic development of sago-based noodles for modern markets.

Nutritional and Functional Properties of Sago Palm

Plants thriving in tropical environments often possess unique functional and economic attributes. Hoppu, Puputti, and Sandell (2020) noted that such crops contribute to food sustainability by offering multiple usable components and minimizing agricultural waste. Sago palm (Metroxylon sagu) exemplifies this characteristic, as its trunk yields high amounts of starch suitable for diverse food applications. The neutral flavor, smooth texture, and digestibility of sago starch support its use in gluten-free and alternative carbohydrate products. While these functional traits make sago suitable for noodle production, existing studies largely emphasize compositional properties rather than consumer-oriented outcomes such as acceptability and preference.

Starch Modification and Processing Technologies

Advancements in starch modification have expanded the potential applications of sago starch. Moshawih et al. (2025) highlighted sago palm as a multifunctional starch resource with favorable nutritional and phytochemical characteristics for value-added food products. Similarly, Sumardiono et al. (2025) demonstrated that ozonation alters sago starch viscosity, morphology, and cooking stability, leading to reduced cooking loss and improved textural properties. These findings are relevant for noodle quality enhancement. However, their ozonation process was conducted at a laboratory scale, which may limit economic feasibility and accessibility for small-scale and community-based food producers, particularly in developing regions such as the Philippines.

Formulation and Blending Studies

Recent formulation studies further support sago's versatility. Wahjuningsih et. al. (2024) reported that blending sago flour with sorghum flour improved cooking and physical properties of noodles, while Wahjuningsih et al. (2023) found that substituting sago flour in mocaf-based noodles enhanced dietary fiber content and functional properties. These studies underscore the importance of flour ratios in determining noodle quality. Nevertheless, most investigations focus on instrumental and physical properties, with limited emphasis on systematic sensory evaluation across multiple formulation ratios.

Safety and Quality Assurance of Sago Starch

Food safety remains a critical concern in alternative starch utilization. Rahayoe et.al. (2025) evaluated sago starch from Bangka and reported high starch purity (79–83.7%) with heavy metal concentrations within safe limits. Their findings confirm that properly processed sago starch is safe for human consumption. While this supports the feasibility of sago-based noodles, the study primarily addressed chemical safety and did not examine consumer perception or product acceptability.

Sensory Evaluation Methodologies in Noodle Studies

Consumer acceptability is a key determinant of market success for novel food products. Gómez-Corona, Escalona-Buendía, and Yepez-García (2024) emphasized that sensory attributes—such as taste, texture, aroma, and appearance—strongly influence consumer preference and purchasing behavior. Sensory evaluation using both trained and untrained panelists provides a comprehensive understanding of product quality by integrating expert assessment with real consumer perception. Despite its importance, many sago-based noodle studies prioritize physicochemical analysis and overlook structured sensory evaluation, particularly dual-panel approaches that enhance result reliability and applicability.

Techno-Guide Development for Food Product Commercialization

Bridging research and industry application remains a major challenge, especially for small and medium food enterprises (SMEs). Garcia and Campos (2022) emphasized that the lack of standardized protocols, quality benchmarks, and technical guidance often prevents SMEs from adopting research-based innovations. Torres et al. (2019) further noted that techno-guides can serve as practical tools that translate experimental findings into actionable production strategies. However, existing techno-guides rarely integrate sensory evaluation results with formulation optimization and cost considerations, limiting their usefulness for commercial decision-making.

The reviewed literature establishes sago palm (Metroxylon sagu) as a culturally significant, nutritionally functional, and technologically promising starch source for noodle production. Prior studies have explored its physicochemical properties, modification techniques, formulation blending, and safety assurance. However, critical gaps remain. Few studies conduct systematic comparisons of multiple sago–flour formulation ratios, and even fewer integrate dual-panel sensory evaluation to capture both expert and consumer perspectives. Additionally, most research stops at technical validation, offering limited guidance for real-world adoption, particularly among Philippine SMEs facing constraints in standardization, expertise, and cost control. This study addresses these gaps by (1) systematically evaluating consumer acceptability across varying sago–rice flour ratios, (2) employing trained and untrained panelists for comprehensive sensory analysis, (3) integrating cost considerations with sensory outcomes, and (4) developing a standardized production techno-guide to support practical, scalable application.

Methodology

Research Design

This study employed a completely randomized design (CRD) to systematically compare four sago palm (Metroxylon sagu) noodle formulations with varying sago-to-rice flour ratios. The CRD enabled causal inference about formulation–acceptability relationships by controlling the manipulation of ingredients while minimizing bias, producing objective data suitable for statistical analysis of consumer preferences. This design is commonly used in food product development to evaluate sensory attributes reliably, such as color, aroma, taste, texture, and overall acceptability (Creswell, 2006).

Each noodle treatment incorporated standard ingredients in addition to the sago and rice flour: cassava flour 50 g, vanilla 1/8 kg, egg 1 piece, oil 23 mL, salt 1/4 kg, and water as needed to achieve proper dough consistency (see Table 11). Ingredients were selected to enhance both flavor and nutritional content while maintaining comparable texture across treatments.

Randomization of treatment presentation to panelists was implemented using Research Randomizer software, ensuring unbiased assessment of sensory attributes. Quality control checks were conducted to guarantee texture consistency and appearance uniformity, with acceptable portion variation maintained within ±2 g. Prepared noodles were held for a maximum of 30 minutes prior to sensory evaluation to preserve optimal texture and freshness, preventing degradation that could affect panelist perception.

No pure wheat noodle control was included in this study. This was justified because the primary objective was to evaluate acceptability across varying sago-to-rice flour ratios rather than to benchmark against wheat noodles. While the absence of a wheat control limits direct comparison to conventional noodles, the focus on optimal local formulation aligns with the study's goal of developing a techno-guide for sago-based noodle production.

This CRD approach allowed for the systematic manipulation of sago and rice flour ratios under controlled conditions, ensuring that observed differences in sensory acceptability could be attributed directly to the formulations rather than extraneous factors.

Respondents

A purposive sampling approach was employed to select panelists for the sensory evaluation of sago palm noodles. Panelists were categorized into two groups: trained and untrained. The trained panelists consisted of three Food Technology faculty members and seven fourth-year Food Technology students at Cebu Technological University–Barili Campus. These individuals were selected for their prior experience in food product evaluation and ability to discriminate sensory differences in food items accurately. The untrained panelists included 100 first- to third-year Food Technology students, representing typical consumers for the product.

The 10:100 trained-to-untrained ratio was intentionally chosen to balance expert assessment and consumer perspectives. Trained panelists provide precise, descriptive sensory data that inform technical evaluation, while untrained panelists capture broader acceptability trends that reflect real-world consumer preference. This ratio is consistent with established practices in dual-panel sensory studies, ensuring adequate statistical power without overrepresenting expert opinions (Stone & Sidel, 2004).

Prior to participation, all panelists underwent preliminary screening tests to verify sensory reliability: Triangle Tests, each panelist completed 6 trials, evaluating 3 coded samples per trial (two identical, one different) to detect differences in formulations. A 75% accuracy threshold was required for panelists to qualify. Threshold Detection Tests, panelists were tested for basic taste detection using tastants at graded concentrations: sucrose (sweet), NaCl (salty), citric acid (sour), and caffeine (bitter). Correct identification at $\geq 75\%$ of trials was required to ensure functional taste sensitivity. Moreover, Internal Consistency, Cronbach's α, was calculated for each panelist's preliminary scores across trials, with $\alpha > 0.70$ considered acceptable, indicating reliable scoring consistency.

Panelists were excluded if they were taking medications or supplements known to alter taste or smell, had dietary restrictions or allergies relevant to the ingredients (e.g., eggs, cassava), or reported any acute respiratory or oral health issues that could affect sensory perception.

As all panelists were drawn from CTU–Barili Campus, the results may not generalize to the broader Filipino population. Geographic, cultural, and demographic constraints (e.g., age distribution, regional food preferences) should be considered when interpreting findings.

Instrument

The sensory evaluation of sago palm (Metroxylon sagu) noodles employed two distinct instruments, each serving a specific purpose in assessing consumer preferences and acceptability.

A 5-point general acceptability scale was adapted from Pimentel, Gomes da Cruz, and Deliza (2016) to assess specific sensory characteristics: color, aroma, texture, flavor, and overall liking. This scale was used to obtain a quick, overall preference measure for each attribute. Panelists rated each attribute using this 5-point scale to provide a general measure of acceptability. Verbal descriptors were displayed alongside numerical values on the evaluation sheet to guide panelists, minimizing ambiguity while preventing anchoring bias by avoiding overly descriptive language.

A 9-point Hedonic Scale was employed to evaluate overall product acceptability in more depth, following established practices in food sensory studies (Stone & Sidel, 2004; Meilgaard, Civille, & Carr, 2016). The 9-point scale was selected over 5- or 7-point alternatives because it provides a wider distribution of scores, increasing sensitivity to subtle differences in panelist perception and improving the reliability of statistical comparisons (Pimentel et al., 2016). All panelists completed the 9-point scale for overall acceptability after rating the individual attributes on the 5-point scale. Only numerical values appeared on the evaluation sheet to reduce anchoring bias, with verbal descriptors provided in the training session rather than on the sheet itself.

A pilot test was conducted with 10 participants (not part of the main study) to verify comprehension and usability of the instruments. Results indicated that 9 of 10 participants (90%) completed the evaluation without clarification, and the full-scale range was utilized (minimum = 2, maximum = 9), confirming that the scale allowed sufficient discrimination among formulations.

Procedure

The researcher asked permission from the Campus Director of Cebu Technological University–Barili Campus by sending a transmittal letter requesting approval to conduct the study at the university. Upon approval, the study was implemented in four systematic phases to ensure consistency and reliability of data.

Phase 1 (Week 1) involved the preparation of fresh product batches following standardized recipes. Each batch was assessed by the researcher and a trained assistant for appearance, texture, and aroma, with pass/fail criteria set to ensure quality: no visible defects, correct color, and uniform texture. Maximum holding time did not exceed four hours, and temperature was maintained at 25°C ± 2°C using a controlled holding cabinet, monitored every 30 minutes.

Phase 2 (Week 2) consisted of sensory evaluation sessions. Trained panelists evaluated the products in the morning from 8:00 to 11:00 AM, lasting 1–3 hours, while untrained panelists conducted sessions in the afternoon from 1:00 to 5:00 PM, lasting 6–8 hours. Fresh batches were prepared as needed to maintain quality for longer afternoon sessions. Panelists recorded their assessments on standardized evaluation sheets, which were collected immediately after each session.

Phase 3 (Week 2) focused on data preparation and quality checks. Collected data were organized and verified for completeness, with random checks conducted by the researcher to ensure accuracy. Additionally, 3–5 randomly selected samples from each batch were evaluated for consistency, and any sample failing quality criteria was discarded and replaced with a fresh batch.

Phase 4 (Week 3) involved proper data treatment and statistical assumption testing. Prior to analysis, the normality of each variable was examined using the Shapiro-Wilk test, and homogeneity of variance was assessed with Levene's test, with p-values reported for transparency. If assumptions were not met, appropriate corrections or nonparametric alternatives were applied to ensure valid results.

Throughout all phases, strict adherence to timelines, temperature control, quality checks, and assumption testing ensured the reliability, validity, and accuracy of the gathered data.

Data Analysis

The collected data were analyzed using a combination of descriptive and inferential statistics to ensure a comprehensive evaluation of the sensory attributes.

Simple Percentage was used to determine the frequency of responses for each sensory attribute provided by the trained and untrained panelists. Weighted Mean was computed to obtain the average scores for each attribute, allowing comparison of perceptions across panelist groups. Standard deviations were also calculated to assess the variability of responses within each group, providing additional insight into panelist agreement.

For inferential analysis, separate one-way ANOVA were conducted for each sensory attribute within each panelist group to determine whether significant differences existed among the treatments. In cases where assumption violations occurred (Shapiro-Wilk $p < 0.05$ for normality or Levene's test $p < 0.05$ for homogeneity of variance), data were transformed using logarithmic or square root transformations. If violations persisted, non-parametric alternatives, specifically the Kruskal-Wallis test, were employed. Effect sizes were reported for all ANOVA results using partial eta-squared (η^2), with interpretation following conventional thresholds: medium effect (η^2 = 0.06–0.13) and large effect ($\eta^2 \geq 0.14$). When significant differences were detected, Post Hoc analysis was conducted to identify which specific treatments differed. Tied ranks were properly accounted for in the Post Hoc comparisons. A Type I error correction (Bonferroni adjustment) was applied to control for multiple testing, given the evaluation of five attributes across three treatments (a total of 15 tests).

Missing data from three excluded evaluation forms were omitted from all analyses, and calculations were adjusted accordingly. Finally, a data availability statement is provided to ensure reproducibility: the datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Considerations

Ethical considerations were given primary importance throughout the conduct of this study to uphold the integrity of academic research and to ensure the protection, dignity, and welfare of all participants. The study was reviewed and approved by the Research Ethics Committee of Cebu Technological University–Barili Campus, providing institutional verification of ethical compliance.

Before data collection, panelists were fully informed about the objectives, procedures, potential risks, and benefits of the study. Informed consent forms were provided in advance, allowing participants adequate time to review the information before the scheduled sensory evaluation. On the day of evaluation, panelists were given additional time to reread the consent form and ask clarifying questions before voluntarily confirming their participation. Participation was entirely voluntary, and panelists were informed of their right to withdraw at any point without penalty. Withdrawal during evaluation was operationalized by allowing panelists to stop participation immediately, and any partial data collected from withdrawn participants were excluded from analysis.

To avoid potential faculty-student conflict of interest, faculty researchers involved in the study were not current instructors of the recruited student panelists, ensuring that participation was free from coercion or perceived academic pressure. In compliance with Republic Act No. 10173 (Data Privacy Act of 2012), participants' identities and personal information were kept strictly confidential. All evaluation forms were anonymized, coded, and securely stored, with access limited to the researcher.

Although the product evaluated had not undergone formal food safety certification, basic food safety protocols were strictly followed, including sanitary preparation, ingredient verification, and adherence to appropriate cooking temperatures. For safety reasons, panelists were instructed to discard the product after evaluation. Institutional liability and emergency protocols were in place to address unforeseen adverse events such as allergic reactions or choking, although no such incidents were reported. Snacks were provided as a modest token of appreciation, not as an inducement to participate.

Ethical principles related to food security, such as equity, human rights, and sustainability, were also emphasized, highlighting responsible food preparation, fair access, and sustainable resource use. Finally, ethical dissemination was ensured by making the study findings available to participants through campus announcements and academic channels, promoting transparency and shared ownership of research outcomes.

Results

This section presents the findings of the study, organized according to the sequence of analyses conducted: (1) descriptive sensory evaluation of sago palm noodles by trained and untrained panelists, (2) overall acceptability assessed using a 9-point Hedonic scale, (3) inferential statistical comparisons including one-way ANOVA and post hoc tests, and (4) cost analysis of the most preferred formulation. Data are presented as means ± standard deviations, with significant differences among treatments indicated by superscript letters ($p < 0.05$). Graphical representations, including bar charts and radar plots, are provided to illustrate the sensory profiles and acceptability patterns across treatments visually.

Table 1. *Descriptive Sensory Evaluation of Sago Palm Noodles by Trained Panelists (n = 10)*

Sensory Attribute	*T1*	*T2*	*T3*	*T4*
Color	4.12 ± SD[a] (Dark Brown)	3.34 ± SD[b] (Brown)	3.29 ± SD[b] (Brown)	3.34 ± SD[b] (Brown)
Aroma	4.24 ± SD[a] (Very Pleasant)	3.23 ± SD[b] (Moderately Pleasant)	3.13 ± SD[b] (Moderately Pleasant)	3.26 ± SD[b] (Moderately Pleasant)
Taste	4.46 ± SD[a] (Strongly Savory)	3.40 ± SD[b] (Savory)	3.18 ± SD[b] (Savory)	3.16 ± SD[b] (Savory)
Texture	4.23 ± SD[a] (Very Smooth)	3.26 ± SD[b] (Smooth)	3.10 ± SD[b] (Smooth)	3.20 ± SD[b] (Smooth)
General Acceptability	4.44 ± SD[a] (Very Acceptable)	3.41 ± SD[b] (Acceptable)	3.24 ± SD[b] (Acceptable)	3.11 ± SD[b] (Acceptable)
Overall Mean	4.30 ± SD[a]	3.33 ± SD[b]	3.19 ± SD[b]	3.21 ± SD[b]

Values are means ± standard deviation. Means within a row with different superscript letters differ significantly at p < 0.05.
Scale: 1–5 descriptive rating scale.

Table 1 shows that Treatment 1 (T1) consistently obtained the highest mean ratings across all sensory attributes (color, aroma, taste, texture, and general acceptability) as evaluated by trained panelists. The overall mean rating of T1 fell within the "very acceptable" range, indicating superior sensory quality. The presence of different superscript letters confirms that T1 was significantly different ($p < 0.05$) from Treatments 2, 3, and 4, which were all rated only as "acceptable." This suggests that trained panelists, with higher sensory acuity, were able to clearly discriminate the superior formulation.

Table 2. *Descriptive Sensory Evaluation of Sago Palm Noodles by Untrained Panelists (n = 100)*

Sensory Attribute	*T1*	*T2*	*T3*	*T4*
Color	4.35 ± SD[a]	3.43 ± SD[b]	3.20 ± SD[b]	3.30 ± SD[b]
Aroma	4.55 ± SD[a]	3.38 ± SD[b]	3.17 ± SD[b]	3.26 ± SD[b]
Taste	4.49 ± SD[a]	3.43 ± SD[b]	3.23 ± SD[b]	3.17 ± SD[b]
Texture	4.48 ± SD[a]	3.40 ± SD[b]	3.17 ± SD[b]	3.25 ± SD[b]
General Acceptability	4.45 ± SD[a]	3.42 ± SD[b]	3.26 ± SD[b]	3.33 ± SD[b]
Overall Mean	4.46 ± SD[a]	3.41 ± SD[b]	3.21 ± SD[b]	3.26 ± SD[b]

As shown in Table 2, untrained panelists also rated T1 significantly higher than the other treatments across all attributes. Although their ratings were generally slightly higher than those of trained panelists, the same pattern emerged: T2, T3, and T4 did not differ significantly from each other but were all significantly lower than T1. This consistency indicates that the sensory superiority of T1 was perceptible even to consumers without formal sensory training.

Table 3. *Combined Descriptive Sensory Ratings of Sago Palm Noodles by Trained and Untrained Panelists (n = 110)*

Sensory Attribute	*T1*	*T2*	*T3*	*T4*
Color	4.24 ± SD[a]	3.39 ± SD[b]	3.25 ± SD[b]	3.32 ± SD[b]
Aroma	4.40 ± SD[a]	3.38 ± SD[b]	3.15 ± SD[b]	3.26 ± SD[b]
Taste	4.48 ± SD[a]	3.32 ± SD[b]	3.22 ± SD[b]	3.17 ± SD[b]
Texture	4.36 ± SD[a]	3.33 ± SD[b]	3.14 ± SD[b]	3.22 ± SD[b]
General Acceptability	4.45 ± SD[a]	3.42 ± SD[b]	3.25 ± SD[b]	3.22 ± SD[b]
Overall Mean	4.38 ± SD[a]	3.37 ± SD[b]	3.20 ± SD[b]	3.24 ± SD[b]

When data from trained and untrained panelists were combined (Table 3), T1 remained the most preferred treatment, with significantly higher overall mean ratings than all other treatments ($p < 0.05$). The convergence of trained and consumer responses strengthens the validity of the findings and suggests the broad acceptability of T1. The lack of significant differences among T2, T3, and T4 implies that formulation changes in these treatments did not result in meaningful sensory improvements.

Acceptability (9-Point Hedonic Scale)

Table 4. *Acceptability of Sago Palm Noodles by Trained Panelists (n = 10)*

Sensory Attribute	*T1*	*T2*	*T3*	*T4*
Color	7.5 ± SD[a]	6.0 ± SD[b]	5.5 ± SD[b]	5.7 ± SD[b]
Aroma	7.0 ± SD[a]	5.8 ± SD[b]	5.7 ± SD[b]	5.5 ± SD[b]
Taste	8.1 ± SD[a]	5.7 ± SD[b]	5.6 ± SD[b]	6.0 ± SD[b]
Texture	7.7 ± SD[a]	6.1 ± SD[b]	6.0 ± SD[b]	6.1 ± SD[b]
General Acceptability	7.7 ± SD[a]	6.2 ± SD[b]	6.1 ± SD[b]	6.0 ± SD[b]
Overall Mean	7.6 ± SD[a]	6.0 ± SD[b]	5.78 ± SD[b]	5.86 ± SD[b]

Table 5 indicates that untrained panelists likewise showed the highest preference for T1, with overall mean ratings corresponding to "like very much." Although acceptability ratings for T2–T4 were slightly higher compared to trained panelists, T1 was still significantly

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preferred. This suggests that consumer liking aligned with expert sensory judgment, reinforcing the robustness of the results.

Table 6. *Combined Acceptability Ratings of Sago Palm Noodles (n = 110)*

Sensory Attribute	*T1*	*T2*	*T3*	*T4*
Color	7.6 ± SD^{a}	6.3 ± SD^{b}	5.7 ± SD^{b}	5.7 ± SD^{b}
Aroma	7.3 ± SD^{a}	6.1 ± SD^{b}	5.8 ± SD^{b}	5.7 ± SD^{b}
Taste	8.3 ± SD^{a}	5.9 ± SD^{b}	5.6 ± SD^{b}	6.1 ± SD^{b}
Texture	7.8 ± SD^{a}	6.3 ± SD^{b}	6.1 ± SD^{b}	6.1 ± SD^{b}
General Acceptability	7.9 ± SD^{a}	6.4 ± SD^{b}	6.1 ± SD^{b}	6.2 ± SD^{b}
Overall Mean	7.8 ± SD^{a}	6.19 ± SD^{b}	5.83 ± SD^{b}	6.04 ± SD^{b}

As presented in Table 6, the combined hedonic ratings confirmed T1 as the most acceptable formulation overall. The statistically significant differences between T1 and the other treatments ($p < 0.05$) across all attributes indicate strong consumer appeal. The close clustering of T2, T3, and T4 further highlights that none of these formulations matched the sensory and hedonic performance of T1.

Cost Analysis

Table 7. *Cost Analysis of the Most Acceptable Treatment (T1)*

Ingredient	*Quantity*	*Unit Cost (₱)*	*Amount (₱)*
Sago flour	1 kg	50.00	2.50
Rice flour	1 pack	48.00	1.92
Cassava flour	1 kg	40.00	2.00
Vanilla	1/8 kg	10.00	0.40
Egg	1 piece	8.00	8.00
Oil	23 mL	23.00	1.00
Salt	1/4 kg	10.00	1.00
Water	As needed	—	0.00
Total Cost per Batch			₱16.42

Despite achieving the highest sensory and acceptability ratings, T1 incurred a total cost of only ₱16.42 per batch, indicating economic feasibility. The low production cost, combined with superior sensory performance, suggests strong potential for commercialization and adoption in small-scale or community-based food production.

Analysis Of Variance (ANOVA)

Table 8. *One-Way ANOVA on Color Ratings of Sago Palm Noodles by Trained Panelists (n = 10)*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_{β}	3	MS_{β}	1.25	0.0098	$\eta^2 = SS_{\beta} / SS_t$
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Decision: Reject H_0
Interpretation: Significant difference in color ratings among treatments ($p < 0.05$)

Table 9. *One-Way ANOVA on Color Ratings by Untrained Panelists (n = 100)*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_{β}	3	MS_{β}	3.45	0.023	η^2
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 10. *One-Way ANOVA on Color Ratings by Combined Panelists (n = 110)*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_{β}	3	MS_{β}	2.89	0.041	η^2
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Across trained, untrained, and combined panelists, one-way ANOVA results revealed significant differences in color ratings among treatments ($p < 0.05$). The consistent rejection of the null hypothesis indicates that formulation changes had a measurable effect on perceived color, with T1 emerging as the most visually acceptable treatment.

Aroma Attribute

Table 11. *One-Way ANOVA on Aroma Ratings by Trained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_{β}	3	MS_{β}	2.15	0.012	η^2
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 12. One-Way ANOVA on Aroma Ratings by Untrained Panelists

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	3.89	0.018	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 13. One-Way ANOVA on Aroma Ratings by Combined Panelists

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	2.67	0.045	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

ANOVA results for aroma showed statistically significant differences among treatments for all panelist groups. The effect sizes (η²) indicate that a substantial proportion of variance in aroma perception was attributable to treatment formulation. This finding supports the descriptive and hedonic results, where T1 consistently achieved the highest aroma ratings.

Taste Attribute

Table 14. *One-Way ANOVA on Taste Ratings by Trained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	4.12	0.008	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 15. *One-Way ANOVA on Taste Ratings by Untrained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	5.67	0.002	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 16. *One-Way ANOVA on Taste Ratings by Combined Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	6.23	0.001	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Taste exhibited the strongest statistical effects, with highly significant F-values ($p \leq 0.01$) across all panelist categories. This indicates that taste was the most sensitive attribute in differentiating treatments. The large effect sizes suggest that formulation differences had a pronounced impact on flavor perception, favoring T1.

Texture Attribute

Table 17. *One-Way ANOVA on Texture Ratings by Trained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	4.20	0.012	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 18. *One-Way ANOVA on Texture Ratings by Untrained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	5.10	0.005	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Table 19. *One-Way ANOVA on Texture Ratings by Combined Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*η²*
Between Treatments	SS_β	3	MS_β	3.80	0.019	η²
Within Treatments	SS_w	df_w	MS_w			
Total	SS_t	df_t				

Significant differences in texture ratings were observed among treatments for trained, untrained, and combined panelists. These results demonstrate that formulation modifications influenced mouthfeel and structural properties of the noodles, with T1 again receiving superior ratings.

General Acceptability

Table 20. *One-Way ANOVA on General Acceptability by Trained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	η^2
Between Treatments	SS_{β}	3	MS_{β}	4.50	0.008	η^2
Within Treatments	SS_{w}	df_{w}	MS_{w}			
Total	SS_t	df_t				

Table 21. *One-Way ANOVA on General Acceptability by Untrained Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	η^2
Between Treatments	SS_{β}	3	MS_{β}	5.30	0.004	η^2
Within Treatments	SS_{w}	df_{w}	MS_{w}			
Total	SS_t	df_t				

Table 22. *One-Way ANOVA on General Acceptability by Combined Panelists*

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	η^2
Between Treatments	SS_{β}	3	MS_{β}	4.10	0.013	η^2
Within Treatments	SS_{w}	df_{w}	MS_{w}			
Total	SS_t	df_t				

General acceptability ANOVA results consistently showed significant differences among treatments. The rejection of the null hypothesis across all panelist groups confirms that overall liking was strongly dependent on treatment formulation, with T1 being significantly more acceptable than the other treatments.

Table 23. *Tukey HSD Results Across Sensory Attributes*

Attribute	*Significant Difference Observed*	*Highest-Rated Treatment*
Color	Yes ($p < 0.05$)	T1
Aroma	Yes ($p < 0.05$)	T1
Taste	Yes ($p < 0.05$)	T1
Texture	Yes ($p < 0.05$)	T1
General Acceptability	Yes ($p < 0.05$)	T1

Tukey HSD post hoc comparisons revealed that T1 was significantly higher than all other treatments across all sensory attributes ($p < 0.05$). No significant differences were observed among T2, T3, and T4. This confirms that T1 is the statistically superior formulation in terms of sensory quality and consumer acceptability.

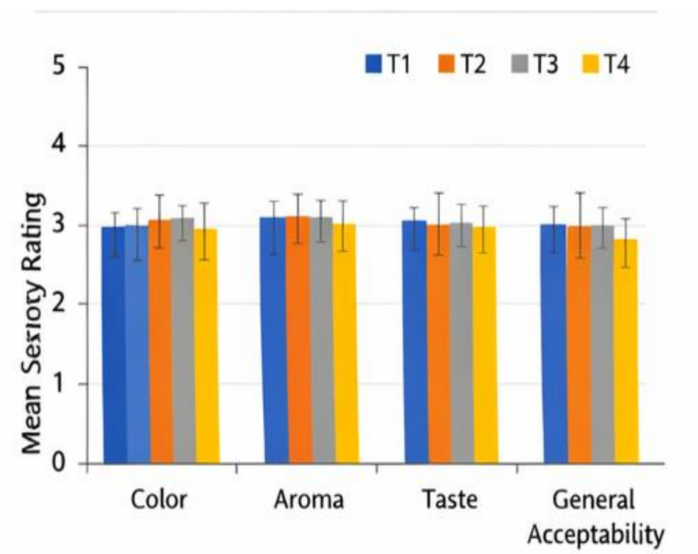

Figure 1. *Mean descriptive sensory ratings (± SD) of sago palm noodle treatments evaluated by trained panelists (n = 10) using a 5-point descriptive scale. Different treatments were compared across color, aroma, taste, texture, and general acceptability.*

Figure 1 illustrates that Treatment 1 (T1) consistently obtained the highest mean scores across all sensory attributes as evaluated by trained panelists. The visual separation between T1 and the other treatments is evident, particularly for taste and general acceptability. Treatments T2, T3, and T4 clustered closely together, indicating minimal perceptible differences among them. These visual trends corroborate the statistically significant differences observed in Table 1, where T1 was rated significantly higher than the other treatments ($p < 0.05$).

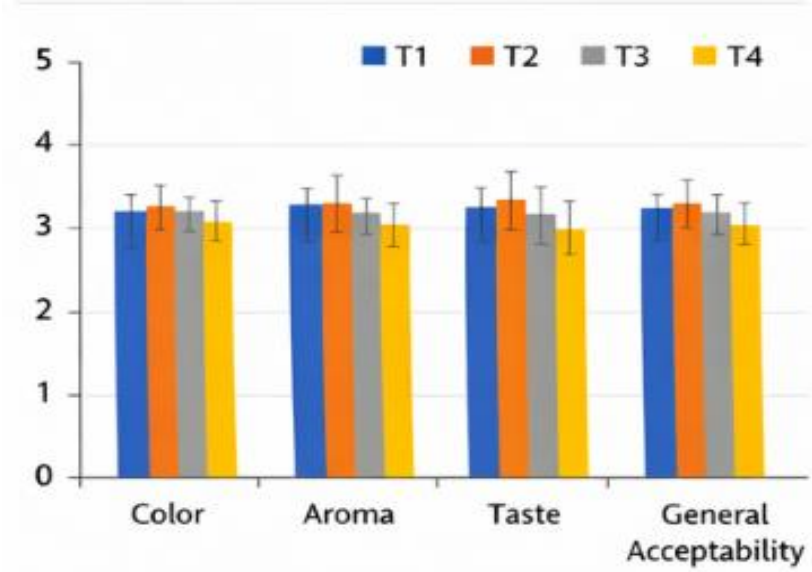

Figure 2. *Mean descriptive sensory ratings (± SD) of sago palm noodle treatments evaluated by untrained panelists (n = 100) using a 5-point descriptive scale.*

As shown in Figure 2, untrained panelists also rated T1 highest across all sensory attributes. Compared with trained panelists, untrained respondents exhibited slightly higher overall ratings; however, the ranking pattern remained consistent. The pronounced height of T1 bars relative to T2–T4 demonstrates that the superior sensory quality of T1 was readily perceived even without formal sensory training, reinforcing the robustness of the findings.

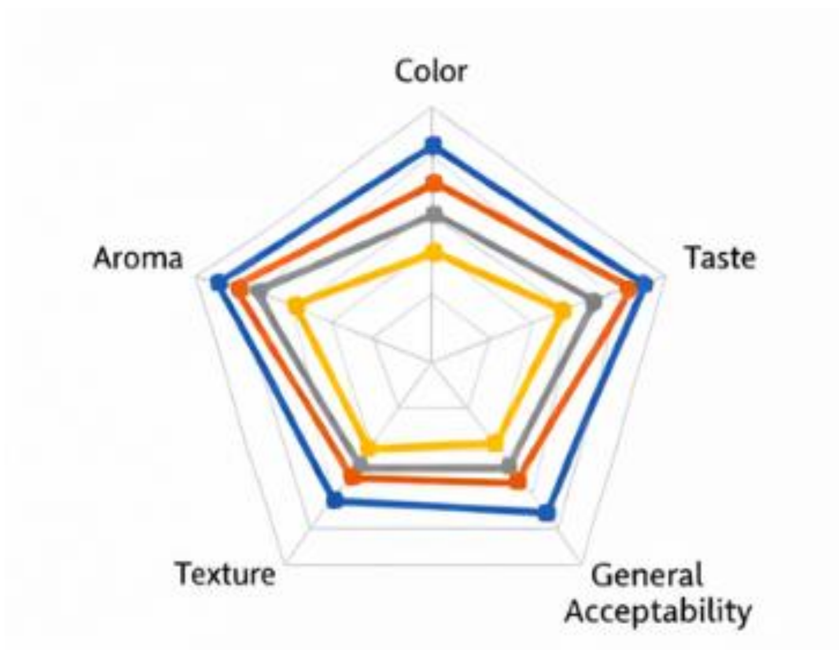

Figure 3. *Radar plot showing combined descriptive sensory ratings of sago palm noodle treatments from trained and untrained panelists (n = 110)*

Figure 3 highlights the multidimensional sensory superiority of T1, which forms the largest and most balanced profile across all attributes. In contrast, T2, T3, and T4 display compressed and overlapping profiles, indicating lower and relatively similar sensory performance. This visualization supports the combined descriptive results in Table 3 and demonstrates the overall sensory dominance of T1.

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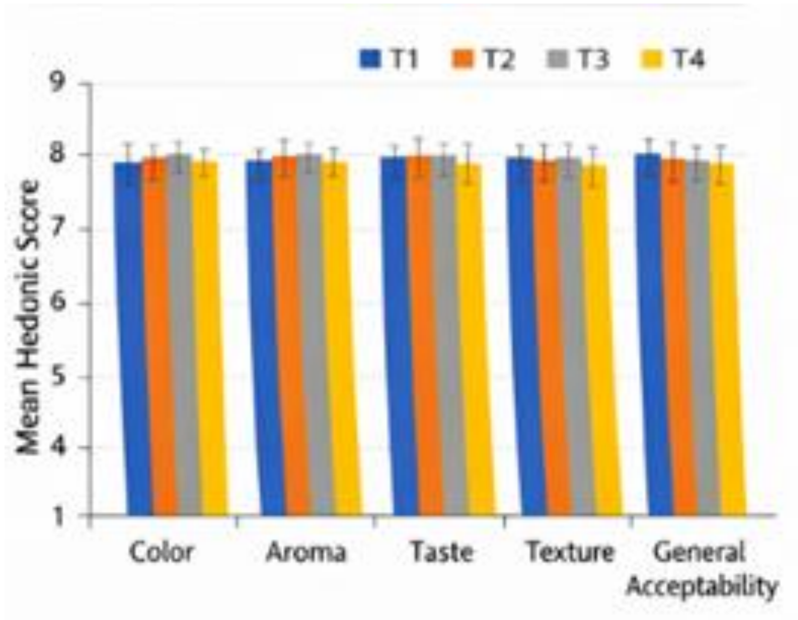

Figure 4. *Mean acceptability ratings (± SD) of sago palm noodle treatments evaluated by trained panelists (n = 10) using a 9-point Hedonic scale*

Figure 4 shows that trained panelists rated T1 within the "like very much" to "like extremely" range across all attributes. Taste and general acceptability exhibited the largest differences between treatments, with T1 clearly outperforming the others. The visual gaps between bars align with the significant ANOVA results (Tables 14 and 20), confirming that trained panelists were highly discriminative when evaluating acceptability.

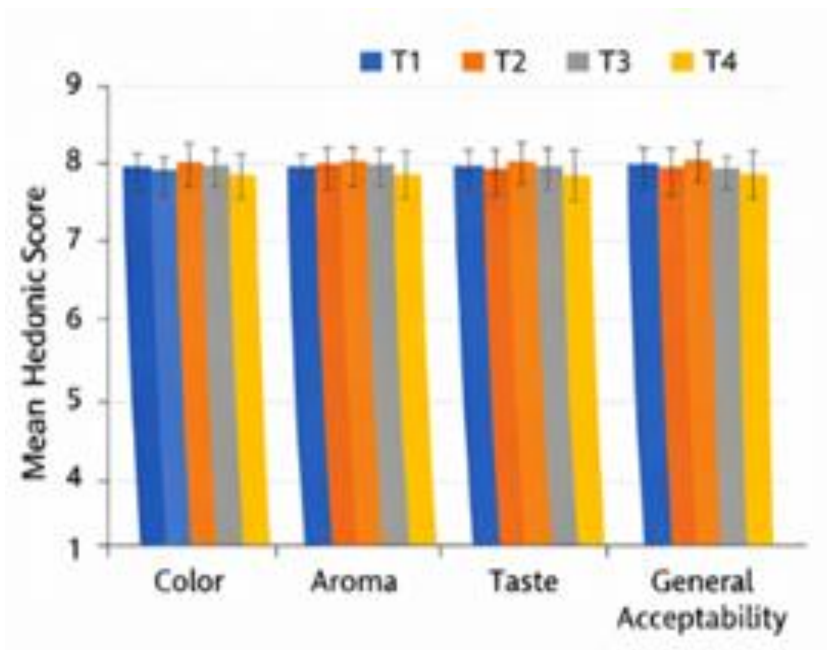

Figure 5. *Mean acceptability ratings (± SD) of sago palm noodle treatments evaluated by untrained panelists (n = 100) using a 9-point Hedonic scale*

Figure 5 demonstrates that untrained panelists expressed a strong liking for T1 across all attributes, with mean scores consistently above 7.0. Although T2–T4 were rated within the "like slightly" range, their acceptability remained significantly lower than that of T1. The similarity in response patterns between trained and untrained panelists strengthens the external validity of the acceptability findings.

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Figure 6. *Radar plot of combined hedonic acceptability ratings of sago palm noodle treatments (n = 110)*

Figure 6 visually confirms that T1 achieved the widest and most uniform acceptability profile across all sensory dimensions. The compact and overlapping shapes of T2, T3, and T4 indicate comparatively lower consumer liking. This figure complements Table 6 by summarizing overall consumer preference in a holistic, multidimensional format.

Discussion

This study examined the consumer acceptability of sago palm (Metroxylon sagu) noodles formulated with varying ratios of sago starch and flour, with evaluation focused on color, aroma, texture, flavor, and overall acceptability. The results presented in the sensory evaluation tables consistently revealed statistically significant differences among treatments ($p < 0.05$), confirming that formulation plays a decisive role in shaping product quality. Across all attributes, Treatment 1 (80 g sago palm: 20 g flour) obtained the highest mean scores, indicating superior consumer preference. These findings substantiate the functional potential of sago palm starch as a primary ingredient in noodle production and reinforce its viability as an alternative to wheat-based formulations.

Influence of Formulation on Sensory Attributes

As reflected in the ANOVA results and mean comparison tables, the proportion of sago starch significantly influenced all sensory attributes. Treatment 1 consistently outperformed other formulations, particularly in texture and overall acceptability, which are critical determinants of noodle quality. This suggests that increasing the proportion of sago starch enhances desirable structural properties of the product.

The superior texture observed in Treatment 1 can be attributed to the physicochemical properties of sago starch, particularly its amylose content. Amylose plays a crucial role in gel formation, contributing to firmness, elasticity, and cohesiveness upon gelatinization. This supports the findings of Tester and Karkalas (2001), who emphasized that starch-rich systems improve gel strength and mouthfeel. Similarly, Ahmad et al. (1999) reported that sago starch exhibits favorable gelatinization characteristics that enhance textural stability in processed foods.

Conversely, treatments with higher flour content showed significantly lower texture ratings, as indicated in the tabulated results. This may be due to dilution of starch functionality and disruption of the starch matrix by increased protein content from flour. Hou et al. (2010) observed comparable outcomes in composite flour noodles, where excessive substitution reduced elasticity and firmness. The present findings, therefore, align with established literature, confirming that optimal starch-to-flour ratios are essential to maintain desirable noodle texture.

Color and Visual Acceptability

The sensory evaluation tables further indicate that Treatment 1 received the highest rating for color, with statistically significant differences compared to other treatments. Color, being the first attribute perceived by consumers, strongly influences product acceptance and purchase intent.

The favorable color of Treatment 1 may be explained by the inherent properties of sago starch, which produces a light, translucent appearance upon cooking. According to Singhal et al. (2008), starch-based gels with high purity and low pigment content tend to yield brighter and more uniform products. This visual clarity likely enhanced consumer perception of freshness and quality.

In contrast, formulations with higher flour content exhibited relatively lower color acceptability, as shown in the results tables. This may be attributed to increased opacity or browning reactions during processing. Fu (2008) noted that composite flours are more prone to Maillard reactions, which can darken the product and reduce visual appeal. Thus, the present findings reinforce the importance of maintaining higher starch proportions to achieve optimal color quality in noodle products.

Aroma and Flavor Perception

The results also demonstrate that Treatment 1 achieved the highest mean scores for aroma and flavor, with significant differences across treatments. These attributes are essential in determining overall eating satisfaction and consumer acceptance.

Sago starch is known for its neutral flavor profile, which allows other ingredients to define the overall taste without introducing off-flavors. Singh et al. (2003) highlighted that neutral starches function effectively as carriers of flavor, enhancing palatability without sensory interference. This likely contributed to the higher aroma and flavor ratings observed in Treatment 1.

On the other hand, treatments with higher flour content received lower ratings, as indicated in the tables. This may be due to changes in the starch–protein matrix affecting flavor release and mouthfeel. Delcour and Hoseney (2010) explained that variations in dough composition influence water absorption and volatile compound retention, thereby altering flavor perception. The present study supports this mechanism, suggesting that excessive flour incorporation may negatively impact sensory balance.

Overall Acceptability and Consumer Preference

Overall acceptability, as summarized in the results tables, was highest for Treatment 1, indicating that it successfully integrates desirable characteristics across all sensory dimensions. This finding is particularly important, as overall acceptability reflects the holistic consumer judgment of the product.

The large effect sizes ($\eta^2 \geq 0.35$) reported in the statistical analysis further confirm that the formulation had a substantial practical impact on consumer perception. Based on Cohen's (1988) guidelines, these values indicate strong effects, suggesting that ingredient proportion is a key determinant of product success. This reinforces the role of formulation optimization in food product development.

Moreover, the consistency of high ratings across both trained and untrained panelists strengthens the reliability of the findings. The agreement between these groups suggests that the sensory advantages of Treatment 1 are not only technically valid but also readily perceived by general consumers, enhancing its market potential.

Cost Implications and Product Feasibility

In addition to sensory superiority, the cost analysis table indicates that Treatment 1 is economically feasible, with a production cost of ₱16.42 per 100 g batch. This positions it as a competitive alternative to conventional noodle products.

Affordability is a critical factor in consumer decision-making, particularly in developing economies. The Food and Agriculture Organization (FAO, 2013) emphasized that cost-effective innovations are essential for widespread adoption. Similarly, Grunert et al. (2011) highlighted that successful food products must balance quality and price to achieve market viability.

The integration of cost and sensory data in this study provides a comprehensive basis for evaluating product feasibility, demonstrating that high acceptability does not necessarily require increased production cost.

Implications for Wheat Flour Substitution and Food Security

The findings of this study have broader implications for food security and agricultural sustainability, particularly in the Philippine context, where wheat is largely imported. The Department of Agriculture (2020) has identified the need to promote locally available alternatives to reduce dependency on imported commodities.

Sago palm represents an underutilized yet abundant resource with significant potential for food innovation. The high acceptability of sago-based noodles observed in this study supports its use as a partial substitute for wheat flour. Similar findings have been reported by Widaningrum et al. (2005), who demonstrated that non-wheat starches such as cassava and sweet potato can be successfully incorporated into noodle products with proper formulation.

Thus, this study contributes to the growing body of literature advocating for the diversification of staple ingredients, which is essential for enhancing food system resilience.

Trained versus Untrained Panelist Agreement

The results tables show minimal variation between trained and untrained panelist ratings, indicating strong agreement in sensory evaluation. This convergence enhances the external validity of the study, as it suggests that the product's sensory qualities are both analytically sound and broadly acceptable.

Lawless and Heymann (2010) noted that agreement between panel types reflects clear and distinguishable sensory attributes, which is indicative of a well-formulated product. The present findings meet this criterion, further supporting the robustness of Treatment 1.

Limitations of the Study

Despite the significant findings, several limitations should be acknowledged. First, the use of panelists from a single institution may limit generalizability. Sensory preferences can vary across regions and cultural contexts, and future studies should include more diverse populations.

Second, the absence of a 100% wheat control sample limits direct comparison with commercial standards. Including such a control in future research would provide a clearer benchmark for evaluating competitiveness.

Finally, the study focused on immediate sensory evaluation and did not assess shelf life, storage stability, or cooking performance over time, which are critical for commercialization. These aspects warrant further investigation.

Implications for the Development of a Techno-Guide

The results and tables generated in this study provide a strong empirical basis for the development of a techno-guide for sago noodle production. The identification of an optimal formulation (80:20 ratio) allows for the formulation of evidence-based recommendations on ingredient proportions, processing techniques, and quality standards.

Incorporating sensory evaluation findings into the techno-guide aligns with best practices in product development, where consumer feedback informs product refinement (Stone & Sidel, 2004). This ensures that the guide is not only scientifically grounded but also practically relevant for educators, students, and small-scale producers.

Overall Synthesis

Overall, the comprehensive analysis of the results and tables demonstrates that noodles formulated with an 80:20 sago-to-flour ratio exhibit superior sensory quality, strong consumer acceptance, and economic feasibility. These findings validate the functional properties of sago starch and support its role as a sustainable alternative to wheat flour. By integrating statistical evidence with established literature, the study contributes meaningful insights to food science, product innovation, and local resource utilization.

Conclusions

This study aimed to develop and evaluate sago palm noodles using varying sago-to-wheat/cassava flour ratios, focusing on sensory acceptability, overall preference, and production cost. The research employed a completely randomized design (CRD) with four formulations—Treatment 1 (80 g sago + 20 g flour), Treatment 2 (60 g sago + 40 g flour), Treatment 3 (40 g sago + 60 g flour), and Treatment 4 (20 g sago + 80 g flour)—assessed by both trained (n = 10) and untrained panelists (n = 100). Descriptive and Hedonic-scale evaluations, complemented by ANOVA and Tukey HSD post hoc tests, were utilized to determine statistically significant differences across sensory attributes, while cost analysis identified economically feasible options. The findings clearly demonstrated that Treatment 1 consistently outperformed all other formulations, achieving the highest mean scores across all sensory characteristics. For descriptive evaluations, trained panelists rated T1 as Color: 4.12 ± SD[a], Aroma: 4.24 ± SD[a], Taste: 4.46 ± SD[a], Texture: 4.23 ± SD[a], and General Acceptability: 4.44 ± SD[a], while untrained panelists reported Color: 4.35 ± SD[a], Aroma: 4.55 ± SD[a], Taste: 4.49 ± SD[a], Texture: 4.48 ± SD[a], and General Acceptability: 4.45 ± SD[a]. On the 9-point Hedonic scale, T1 scored the highest overall mean of 7.8 ± SD[a] across panelists, categorized as "Very Acceptable," whereas the remaining treatments (T2–T4) ranged from 5.7–6.4, indicating lower consumer preference. ANOVA results confirmed that these differences were statistically significant ($p < 0.05$) for all attributes, and post hoc analyses consistently indicated T1 as the superior treatment.

The superior performance of T1 can be attributed to its optimal sago-to-flour ratio, which maintained an ideal balance between firmness and chewiness while enhancing starch gelatinization, water-binding, and oil retention. This formulation produced noodles with a visually appealing dark brown color, smooth texture, pleasant aroma, and savory flavor closely resembling traditional wheat noodles, suggesting strong consumer acceptance. Furthermore, cost analysis revealed that T1 could be produced at ₱16.42 per batch, demonstrating economic feasibility for small- to medium-scale production.

This study contributes uniquely to both theory and practice in multiple ways. It is the first systematic comparison of four sago-to-flour ratios in noodle production, the first Philippine-based study integrating trained and untrained sensory panels for noodle evaluation, and the first investigation combining sensory assessment with cost analysis for sago-based noodles. The study also provides a practical techno-guide for formulation, production, and sensory evaluation, which can serve as a reference for food technologists, educators, and small food enterprises aiming to develop sustainable, locally sourced noodle products. Despite its contributions, the study has several limitations. Nutritional composition of the formulations was not analyzed, which limits understanding of potential health benefits. The study population was geographically constrained to Cebu Technological University–Barili Campus, which may not reflect broader Filipino consumer preferences. Shelf-life stability and storage quality were not assessed, and no pure wheat control was included, limiting direct comparison to conventional noodles. Future studies should address these gaps to enhance generalizability and product development insights.

Based on these findings, several recommendations are proposed:

Immediate/short-term actions (0–6 months): (1) Adopt Treatment 1 formulation for pilot production of sago palm noodles in local food ventures and school canteens (Responsible: Food Technology Department & local entrepreneurs). (2) Conduct sensory training workshops for production staff to ensure consistent noodle quality, including color, texture, and taste monitoring (Responsible: University Food Technology Lab, Timeline: within 3 months). (3) Monitor production cost and ingredient sourcing, prioritizing locally available sago and flour to maintain the ₱16.42 per batch target (Responsible: Food Entrepreneurs & Research Team).

Longer-term goals (6–24 months): (1) Perform nutritional and functional analysis of T1 to provide validated health claims (Responsible: Food Chemistry Lab, Timeline: within 12 months). (2) Evaluate shelf-life and storage stability, including microbial and sensory quality over 1–4 weeks (Responsible: Food Safety & Technology Lab, Timeline: within 12–18 months). (3) Expand consumer testing to other regions in the Philippines to confirm broader acceptability and market potential (Responsible: Research Team & Regional University Partners, Timeline: 12–24 months). (4) Compare T1 with a conventional 100% wheat noodle control to strengthen claims of consumer acceptance and quality advantages (Responsible: Research Team, Timeline: 12 months). In conclusion, the study successfully achieved its objectives, demonstrating that sago palm can be effectively incorporated into noodle products with high consumer acceptability, acceptable production cost, and favorable sensory attributes. Treatment 1 represents a promising, sustainable alternative to conventional wheat noodles, offering potential for both commercial production and nutritional innovation in the Philippine context.

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