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NUTRITIONAL AND SENSORY ASSESSMENT OF *MANGIFERA INDICA* LEAF: A SUSTAINABLE FOOD INNOVATION

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ABSTRACT
This study explores the underutilized potential of young mango leaves (Mangifera indica L.) as a novel, nutritious snack in the form of chips. Utilizing an experimental and descriptive quantitative research design, the study investigated the phytochemical profile, sensory attributes, and shelf-life stability of chips made from young mango leaves. Phytochemical screening revealed the presence of bioactive compounds such as flavonoids, phenolics, tannins, glycosides, and triterpenoids, indicating potential health benefits and safety for human consumption. Sensory evaluation, conducted using a 9-point Hedonic Scale across four flavors (Classic, Barbecue, Cheese, and Sour Cream), demonstrated high levels of consumer acceptability, with mean ratings indicating strong preferences for taste, aroma, and texture. Shelf-life analysis, conducted over five weeks, confirmed product stability with minor sensory changes, supporting the chips' commercial viability. The findings advocate for the sustainable utilization of agricultural by-products and introduce a potential marketable product aligned with health and environmental goals.

KEYWORDS: *Young Mango Leaves, Phytochemicals, Sensory Evaluation, Snack Innovation, Shelf-Life Stability, Sustainable Food Products*

1. INTRODUCTION

Mangifera indica L., commonly known as mango, is a highly valued tropical fruit widely cultivated across Southeast Asia, particularly in countries such as the Philippines, India, and Thailand. While the fruit is extensively utilized for its nutritional and economic value, the leaves—especially the young, tender ones—remain an underutilized by-product [1]. Traditionally, mango leaves have been employed in various ethnomedicinal practices due to their rich phytochemical profile, which includes bioactive compounds such as mangiferin, flavonoids, carotenoids, phenolic acids, and other antioxidants [1, 2, 3, 4, 5, 6, 7]. These compounds have been associated with several therapeutic properties, including antidiabetic, antimicrobial, anti-inflammatory, and antioxidant effects [1, 2, 3, 4, 5, 6, 7]. Despite these well-documented nutritional and medicinal attributes, young mango leaves are largely overlooked in the contemporary food industry, often discarded as agricultural waste. This underutilization represents a significant missed opportunity, especially given the growing global demand for healthier, plant-based, and diversified snack alternatives [8, 9, 10]. Current food systems heavily rely on a limited number of staple crops, leading to concerns about dietary diversity and sustainability [9, 10]. Underutilized plants, like mango leaves, offer a promising avenue to address these challenges due to their adaptability, nutritional superiority, and potential to enhance food security [8, 9, 10].

Research Gaps

While the phytochemical composition and health benefits of mango leaves are well-established, a critical gap exists in their practical application as a novel food product, specifically as a marketable snack like chips. Comprehensive studies focusing on the transformation of young mango leaves into directly consumable snack forms, evaluating their sensory appeal, consumer acceptability, and shelf-life stability, remain limited. Existing research predominantly focuses on extracts for pharmaceutical or medicinal purposes rather than their integration into everyday food products to promote sustainable consumption and provide readily available nutritious options [3, 6, 7]. Understanding the specific sensory characteristics (e.g., taste, texture, aroma) and optimizing the flavor profile of young mango leaves in a processed snack format is crucial for their successful market integration and consumer adoption [11, 12, 13]. Furthermore, robust shelf-life analyses tailored to such novel products are essential to ascertain their commercial viability and ensure product quality over time [11, 12, 13].

This study aims to bridge these gaps by investigating the feasibility of converting young *Mangifera indica* leaves into an acceptable, nutritious, and shelf-stable snack alternative. This research directly supports the United Nations Sustainable Development Goals (SDGs), specifically:

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- **SDG 12: Responsible Consumption and Production**, by minimizing food waste and promoting the valorization of agricultural by-products.
- **SDG 3: Good Health and Well-being**, by contributing to the development of nutritious, functional foods that support better dietary practices.

Objectives of the Study

This study aims to explore the potential of young *Mangifera indica* leaves as a sustainable snack food by addressing the following specific objectives:

1. To analyze the phytochemical composition of young mango leaves and identify their potential health benefits.
2. To assess the quality of the developed mango leaf chips in terms of:
   2.1. Sensory attributes (appearance, taste, texture, and aroma)
   2.2. Shelf-life stability over a defined storage period
3. To evaluate the level of consumer acceptability and determine its implications for the market viability of young mango leaf chips.

2. METHODS

2.1. Research Design This study rigorously employed a multi-faceted research design to comprehensively evaluate the novel food product. An **experimental research design** was primarily utilized to assess the impact of various formulations and processing techniques on the flavor profile and consumer acceptability of chips derived from young mango leaves. This design facilitated controlled observation of the effects of specific interventions. Complementing this, a **quantitative descriptive study design** was integrated to systematically characterize the product's quality over time. This involved meticulous sensory evaluation and detailed shelf-life analysis, enabling the precise ascertainment of critical quality attributes and their evolution. The combination of these designs provided a robust framework for both evaluating the efficacy of the product development process and thoroughly describing the inherent characteristics and stability of the final young mango leaf chips.

2.2. Research Locale and Participants The administration of the evaluation questionnaire was conducted across two campuses of the Nueva Ecija University of Science and Technology: the Sumacab Campus and the General Tinio Campus, both located in Cabanatuan City, Philippines.

Participants for this study were carefully selected using a purposive sampling method. This approach was chosen to ensure that the sample comprised individuals with specific expertise and characteristics directly relevant to the research objectives, particularly in sensory evaluation and food technology. The total sample size consisted of 50 individuals, categorized as follows:

Table 2 ***Distribution of Research Participants by Category***

Participant Category	Number of Participants (n)	Percentage (%)
Students (related to food senses)	30	60
Licensed Teachers (TLE & food-related)	10	20
Experts (NCII holders in Food/Food Technology)	10	20
Total	**50**	**100**

This structured selection ensured that the sensory and acceptability evaluations benefited from diverse perspectives, including those with theoretical knowledge, pedagogical experience, and practical industry expertise in food-related domains.

2.3. Research Instruments and Validation Data collection was systematically conducted using a meticulously designed and validated questionnaire, comprising distinct sections for comprehensive sensory evaluation and the assessment of overall product acceptability. The questionnaire's methodological rigor was ensured through a thorough expert review process, which confirmed its relevance, clarity, and exhaustive coverage of all essential research components. This validation process yielded a Content Validity Index (CVI) of 1, unequivocally indicating the questionnaire's utmost relevance and its capacity to comprehensively capture the intended data with high fidelity.

For the sensory evaluation of attributes such as appearance, color, aroma, taste, and texture, a standardized 9-point Hedonic Scale was employed. This scale ranged from "1: Dislike Extremely" to "9: Like Extremely," enabling a nuanced quantification of consumer preferences and sensory perceptions. Concurrently, the overall acceptability of the young mango leaves chips was evaluated using a 5-point Likert rating scale, which provided a robust measure of general consumer approval, with ratings spanning from "1: Completely

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Unacceptable" to "5: Completely Acceptable." The consistent application of these validated instruments ensured the reliability and interpretability of the collected data.

2.4. Data Gathering Procedures Information was collected from various sources and participants to address the research objectives. The procedures for preparing the young mango leaves chips and conducting analyses were as follows:

- **Phytochemical Testing:** Conducted with the help of a professional to identify and analyze bioactive compounds (flavonoids, tannins, phenolics, alkaloids, terpenoids) present in young mango leaves. This ensured the presence of desired bioactive compounds and confirmed safety.
- **Sensory Evaluation:** Assessed taste, texture, aroma, and overall sensory experience of the chips using human senses. The evaluation involved experts, teachers, and students using a 9-point Hedonic Scale.
- **Processing Technique (Formulation):** The researchers underwent six trials to optimize the formulation of the young mango leaves chips, experimenting with different ingredients and quantities. The final formulation involved removing baking powder to achieve a crunchier texture and utilizing a freezing method.
- **Shelf-Life Analysis:** Tracked the quality of the chips over 5 weeks, observing changes in appearance, color, aroma, taste, and texture. This assessment aimed to determine the period during which the product retains its desired sensory characteristics.

2.5. Statistical Data Analysis The quantitative data collected from the sensory evaluation and overall acceptability ratings were meticulously analyzed using descriptive statistics, primarily weighted means. This statistical approach was employed to accurately interpret the varying levels of consumer perception and product quality. For the sensory evaluation attributes (appearance, color, aroma, taste, and texture), a 9-point Hedonic scale was utilized. The interpretation of weighted means for this scale ranged from "Dislike Extremely" (1.00) to "Like Extremely" (9.00), providing a nuanced understanding of consumer preferences. The overall acceptability of the young mango leaves chips was assessed using a 5-point Likert rating scale, with weighted mean interpretations ranging from "Completely Unacceptable" (1.00-1.80) to "Completely Acceptable" (4.21-5.00). This comprehensive statistical framework ensured a robust and objective assessment of the product's quality and market potential.

Table 1 ***Interpretation of the 9-Point Hedonic Scale for Sensory Evaluation***

Scale Point	Verbal Interpretation
9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like Nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

2.6. Research Ethics The study was conducted with appropriate ethical considerations, ensuring informed consent from participants and maintaining confidentiality of collected data.

3. RESULTS

This section presents a comprehensive overview of the findings from the phytochemical analysis, sensory evaluation, and shelf-life assessment of the young mango leaves chips, offering insights into their nutritional potential, consumer appeal, and stability.

3.1. Phytochemical Composition Phytochemical screening of the young mango leaves revealed the significant presence of several beneficial secondary metabolites. These include phenolics, triterpenoids, flavonoids, glycosides, and tannins. The identification of these compounds is crucial, as they are widely recognized for their diverse health-promoting properties. Phenolics and flavonoids, for instance, are potent antioxidants known to combat oxidative stress and reduce the risk of chronic diseases [2, 3]. Triterpenoids have been associated with anti-inflammatory and anti-cancer activities [4], while tannins possess astringent properties and contribute to antioxidant defense [5]. Glycosides also represent a broad class of compounds with various biological activities [6]. Notably, the absence of alkaloids

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in the young mango leaves is an important finding, as it indicates the non-toxic nature of the raw material, thereby supporting its safety for human consumption in food applications [7]. These findings collectively affirm the substantial nutritional value and potential health benefits derived from incorporating young mango leaves into dietary products.

3.2. Sensory Evaluation of Young Mango Leaves Chips Sensory evaluation is a critical component in the development and acceptance of novel food products, directly influencing consumer preference and market success [14, 15]. This study conducted a comprehensive sensory assessment across four distinct flavors of young mango leaves chips: Classic, Barbeque, Cheese, and Sour Cream. The evaluation panel comprised a diverse group of 50 individuals, including food experts, experienced teachers in food-related subjects, and students with specialized knowledge in food senses. All four flavors consistently received high scores on the 9-point Hedonic scale, with overall interpretations predominantly falling within the "like very much" range. This strong positive reception indicates a significant consumer preference across all evaluated sensory attributes: appearance, color, aroma, taste, and texture.
Specifically:

- The **Classic Flavor** garnered an overall weighted mean score of 7.88, which is equivalent to "like very much," highlighting its inherent appeal.
- The **Sour Cream Flavor** also demonstrated high acceptability, achieving an average weighted mean of 7.89, interpreted as "like very much." Notably, the texture of the Sour Cream variant was consistently rated as its most highly preferred characteristic, suggesting successful textural innovation in this formulation.

These results underscore the successful development of palatable and appealing snack products from young mango leaves, demonstrating their potential to satisfy diverse consumer tastes.

3.3. Shelf-Life Analysis The shelf-life study was crucial for determining the commercial viability and stability of the young mango leaf chips. The quality of the chips was meticulously tracked over a five-week period, from March 22 to April 19, 2024, observing changes in critical sensory attributes. Maintaining product quality throughout its shelf life is paramount for consumer satisfaction and market acceptance [16, 17].

- **Weeks 1 & 2:** During the initial two weeks, the chips exhibited well-maintained quality. They were characterized by smooth, even slices, a uniform golden-brown color, a distinct salty aroma, a mild bitter aftertaste, and a desirable crunchy yet tender texture. This indicates good initial product stability.
- **Week 3:** A noticeable observation in the third week was the onset of oil separation. However, at this stage, this phenomenon did not significantly impair the overall quality of the chips, with other sensory attributes like taste and texture largely remaining consistent. Oil separation can be a common issue in fried snack products due to lipid migration [18].
- **Week 4:** The chips continued to show signs of oil separation, accompanied by a slight lightening of color. Despite these changes, the fundamental appearance, taste, and the desired crunchy and tender texture remained consistent, indicating acceptable quality retention.
- **Week 5:** By the fifth week, oil separation persisted, the appearance showed slightly wavy slices, and the color had lightened further. While the texture became crunchy, it was noted to be less tender compared to earlier weeks, though the taste profile remained consistent.

Overall, the shelf-life analysis demonstrated that the young mango leaves chips maintained acceptable sensory qualities over the observed five-week period. Although minor changes related to oil and texture were noted towards the end of the study, the product retained sufficient quality to support its potential for market distribution and consumption within a reasonable timeframe. Further research could explore advanced packaging technologies or natural preservatives to extend shelf life beyond this period [17].

3.4. Level of Acceptability of Young Mango Leaves Chips The ultimate success of any novel food product hinges on its consumer acceptability [19, 20]. The overall acceptability of the young mango leaf chips was assessed using a 5-point Likert scale, yielding a high average weighted mean rating of 4.57. This score is consistently interpreted as "Completely Acceptable," signifying a strong positive reception from the diverse group of respondents.
Detailed analysis of specific aspects contributing to overall acceptability revealed several key factors:

- **Taste and Flavor:** Respondents overwhelmingly agreed on the deliciousness of the chips, with a weighted mean of 4.53, and affirmed that flavor is a key determinant of their satisfaction (4.67 AWM). These findings underscore the critical role of sensory attributes in driving consumer preference [19, 21].
- **Snack Option Viability:** The chips were widely perceived as an acceptable snack option, demonstrated by a weighted mean of 4.50. This indicates a positive consumer perception of the product's integration into daily snacking habits [22].

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- **Market Potential:** The study revealed a strong consensus regarding the potential for marketing and selling these chips within the community, evidenced by a weighted mean of 4.57. This suggests promising commercial prospects for the product [23, 24].
- **Packaging Appeal:** The packaging of the young mango leaves chips was also found to be highly appealing and acceptable, with a weighted mean of 4.60. Effective packaging plays a crucial role in initial consumer attraction and brand perception, influencing purchasing decisions [25, 26].

The consistently high level of acceptability across all assessed aspects underscores that the robust sensory analysis significantly influenced the overwhelmingly positive reception of the product. These results strongly support the potential for young mango leaves chips to be successfully introduced into the market as a desirable and nutritious snack alternative.

Table 3 *Level of Acceptability of Young Mango Leaves Chips by Respondents*

Acceptability Aspect	Weighted Mean (AWM)	Interpretation
Overall Acceptability	4.57	Completely Acceptable
Chips are delicious	4.53	Completely Acceptable
Flavor is a key determinant of satisfaction	4.67	Completely Acceptable
Acceptable as a snack option	4.50	Completely Acceptable
Strong potential for marketing and selling	4.57	Completely Acceptable
Packaging is appealing and acceptable	4.60	Completely Acceptable

4. DISCUSSION

The findings of this study strongly support the viability of young mango leaves as a valuable ingredient for developing nutritious and appealing snack products. The detected phytochemicals, such as phenolics, triterpenoids, flavonoids, glycosides, and tannins, reinforce the inherent nutritional value and safety of mango leaves, aligning with existing literature that highlights their antioxidant, anti-inflammatory, and other beneficial properties [1, 2, 3, 4, 5, 6]. The absence of alkaloids further confirms their non-toxic nature, addressing a critical safety aspect for food product development [7]. This positions young mango leaves as a promising, underutilized source of bioactive compounds that can contribute to healthier dietary options.

The high consumer acceptability across all tested flavors (Classic, Barbeque, Cheese, and Sour Cream) is a significant finding [14, 15]. The "like very much" ratings for taste, texture, and aroma indicate that the developed processing techniques effectively transformed the raw leaves into a desirable snack. This addresses the previously identified gap in understanding the sensory appeal of young mango leaves when processed into chips. The iterative formulation process, including the removal of baking powder and the adoption of a freezing method, was crucial in achieving the desired crunchy texture and overall sensory profile, demonstrating a successful approach to product optimization.

The shelf-life analysis, while showing some minor changes like oil separation and slight texture alteration over five weeks, confirmed the chips' ability to retain acceptable quality for a commercially relevant period [16, 17]. This is vital for marketability and distribution, ensuring consumer satisfaction over time. The observations of gradual changes in sensory attributes over time are consistent with typical food product degradation, highlighting the importance of proper packaging and storage conditions [18]. Future research could investigate optimized packaging solutions, potentially incorporating desiccants like non-indicating silica gel, which is FDA-approved for food contact, to further extend shelf life and prevent moisture-related quality degradation [17].

The strong consensus among experts, teachers, and students regarding the overall acceptability and market potential of young mango leaf chips underscores the product's commercial promise [19, 23, 24]. The feedback and iteration process, where consumer insights led to recipe adjustments (e.g., reducing salt content, adjusting batter thickness, increasing mango leaf content), exemplifies a market-driven product development approach. This iterative refinement process is critical for developing products that genuinely meet consumer preferences and enhance their likelihood of market success.

This study contributes significantly to the field by demonstrating a practical application for an agricultural by-product, aligning with principles of sustainability and waste reduction [8, 9, 10]. It provides a foundation for future research on novel food products from underutilized plant resources, particularly in the context of addressing nutritional needs and promoting healthier snack alternatives. Further studies could explore the specific bioavailability of the identified phytochemicals in the chip form, optimize processing methods for nutrient retention, and conduct larger-scale consumer trials to assess market demand and scaling potential. Additionally,

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investigations into different mango leaf varieties and their impact on phytochemical composition and sensory properties would be valuable.

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