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Development and sensory acceptability of bamboo leaf tea flavored with lime and pandan

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ABSTRACT

The increasing demand for functional beverages has encouraged the exploration of plant-based ingredients with potential health benefits. However, bamboo leaves, despite being rich in antioxidant compounds, remain largely underutilized in beverage development, particularly in combination with locally available flavoring plants. This study aimed to develop and evaluate Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan as a functional beverage using locally sourced ingredients. A developmental and descriptive-experimental research design was employed to formulate the beverage using varying proportions of bamboo leaves while maintaining constant amounts of lime, pandan, sugar, and water. Phytochemical screening revealed the presence of phenols, flavonoids, tannins, essential oils, and anthraquinones, indicating antioxidant potential. Sensory evaluation among consumers and food experts showed high acceptability in terms of color, aroma, taste, and smoothness, while statistical analysis indicated no significant differences among formulations. Cost analysis confirmed its feasibility for small-scale production. Future studies should examine the shelf life, microbial safety, and nutritional stability of the beverage to support commercialization.

Keywords: Bamboo leaf tea, functional beverage, antioxidant compounds, sensory acceptability, product development.

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INTRODUCTION

Traditionally recognized for its industrial applications, bamboo has gained attention for its potential as a source of natural antioxidants and bioactive compounds. According to Indira et al. (2022), every part of the bamboo plant, from the rhizome to the leaves, roots, shoots, and seeds, possesses therapeutic properties that have been explored for their health benefits. Recent studies have highlighted the significant antioxidant content of bamboo, suggesting its potential as a valuable component of natural medicine.

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For generations, people have relied on nature's resources to meet their daily needs. In the province of Isabela, the municipality of San Guillermo has served as a key supplier of bamboo to neighboring communities. Bamboo has been widely utilized in constructing traditional huts, decorations for various occasions, and furniture such as chairs and tables. However, during bamboo harvesting, the leaves are often discarded and left to decompose, leaving a valuable resource unused. Although decomposition is a natural process, simply leaving the leaves behind means missing opportunities for their productive use. These leaves have potential applications in various industries, including agriculture and food and beverage production, yet they remain largely underutilized. As a result, their full value remains untapped.

A study by Singhal (2023) showed that bamboo extract may help prevent diseases such as diabetes, cancer, cardiovascular conditions, and age-related ailments. Bamboo leaves, in particular, are rich in flavonoids, natural compounds with antioxidant and anti-inflammatory properties that contribute to overall health. Continued research has revealed even more health benefits of bamboo leaves, reinforcing their potential in disease prevention and wellness promotion.

Research conducted by Kimura et al. (2022) recognized bamboo as a medicinal plant that has been used in traditional medicine and food preservation in Japan for centuries. Their study identified numerous bioactive compounds in bamboo leaf extract with therapeutic properties, demonstrating potential in preventing infectious, inflammatory, cardiovascular, metabolic, and neurological diseases. Specific flavonoids, such as orientin and vitexin, were also found to positively influence gut microbiota, which plays a crucial role in overall health. These findings indicate that bamboo leaves could serve as a valuable natural resource for developing diverse pharmacological applications.

Despite the growing demand for natural and refreshing beverages, a gap remains in the availability of cold tea drinks that incorporate locally sourced, health-enhancing ingredients. Many commercial iced teas rely on artificial flavorings, excessive sugar, and preservatives, which may not appeal to health-conscious consumers. Although herbal teas have gained popularity, there has been limited research and product development focused on utilizing bamboo leaves, a rich source of antioxidants, as a key ingredient. This study aims to address this gap by exploring the potential of bamboo leaf tea as a naturally refreshing beverage rich in bioactive compounds, offering an alternative to conventional cold tea drinks.

To enhance the appeal and health benefits of bamboo leaf tea, this study incorporates lime and pandan, both known for their aromatic qualities and medicinal properties. Lime adds a zesty citrus flavor, while pandan contributes a subtle sweetness and soothing aroma that enhances the overall sensory profile. By combining these three natural ingredients, this research seeks to develop an innovative, refreshing, and functional cold tea beverage that provides a healthier alternative to sugary iced teas. Moreover, this study promotes the use of sustainable and locally available ingredients that support both wellness and environmental sustainability.

The development of Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan aligns with several Sustainable Development Goals (SDGs). This study contributes to SDG 1 (No Poverty) by providing local bamboo farmers with a sustainable source of income, thereby improving their livelihoods. By emphasizing the nutritional benefits of bamboo leaf tea, which can enhance food security and promote healthy dietary choices, the study also supports SDG 2 (Zero Hunger). Furthermore, by examining the tea's antioxidant properties and potential health benefits, this research advances SDG 3 (Good Health and Well-being) by encouraging healthier lifestyles.

In addition, raising awareness about the benefits of bamboo tea promotes SDG 4 (Quality Education) by educating communities about its health advantages and sustainable uses. The development of this product also creates economic opportunities for women involved

in bamboo farming and tea production, thereby supporting SDG 5 (Gender Equality). Moreover, utilizing bamboo leaves for tea reduces waste and contributes to SDG 13 (Climate Action) by encouraging sustainable agricultural practices that minimize environmental impact. By strengthening local businesses and fostering innovation, this study also contributes to SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

The study further supports SDG 8 (Decent Work and Economic Growth) by generating employment and boosting local economies, particularly in remote areas. Typically, bamboo leaves are discarded during harvesting; however, this research aims to utilize Buho bamboo (Schizostachyum lumampao), highlighting the health benefits of this innovative beverage while addressing the underutilization of bamboo leaves and promoting wellness and sustainability. Finally, this study underscores the importance of SDG 17 (Partnerships for the Goals) by fostering collaboration among local farmers, researchers, and stakeholders in the food and beverage industry.

The development of Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan addresses the underutilization of bamboo leaves while promoting health and sustainability. This study is guided by the concept presented in the study entitled "Consumers' Acceptability and Nutritive Value of Amaranth (Amaranthus) and Lemongrass (Cymbopogon citratus) with Philippine Lime (Citrofortunella microcarpa), Aqueous Extract Mixed Juice Drink," which highlighted the utilization of lime, pandan, and sugar as key ingredients. By incorporating these components, the research aims to enhance both the flavor and the bioactive compound content of the tea while providing a healthier alternative to sugary beverages.

Statement of the problem

This study aimed to develop Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan and to evaluate its characteristics and acceptability. Specifically, it sought to examine the processes involved in its development, determine its chemical properties, assess its level of acceptability based on selected sensory attributes and across different groups of respondents, analyze variations in acceptability across different proportions and formulations, and estimate the production cost as a basis for commercialization.

1. What are the processes involved in developing Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan?
2. What are the chemical characteristics of Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan?
3. What is the level of acceptability of the developed Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan in terms of color or appearance, odor or aroma, taste, and smoothness?
4. What is the level of acceptability of the developed Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan as evaluated by young adults aged 20 to 29 years old, adults aged 30 to 44 years old, middle aged adults aged 45 to 49 years old, and food and beverage experts?
5. Does the level of acceptability of the developed Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan differ significantly when tested across varied proportions?
6. Does the level of acceptability of the developed Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan differ significantly across varied formulations as evaluated by different groups of respondents?
7. What is the production cost incurred in the preparation of Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan as a basis for commercialization?

METHODOLOGY

This study utilized locally available ingredients and standard food preparation tools to develop Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan. The primary ingredients included fresh bamboo leaves, bamboo leaf extract, Philippine lime juice, pandan leaves, refined sugar, and water. Three formulations were prepared by varying the amount of fresh bamboo leaves used during extraction while keeping the other ingredients constant. Basic kitchen tools and food preparation equipment were used throughout the process to ensure proper measurement, preparation, and storage of the beverage.

The preparation began with harvesting fresh bamboo leaves, which were immediately stored in a sealed container to preserve their natural properties. The leaves were thoroughly washed to remove impurities before extraction. Water was heated to boiling, and the bamboo leaves were simmered in the boiling water to extract their flavor and beneficial compounds. After extraction, the mixture was strained to remove solid particles, leaving a clear bamboo leaf extract that was allowed to cool before further processing.

The refreshing tea was then prepared by combining the bamboo leaf extract with pandan leaves, Philippine lime juice, and refined sugar. The mixture was heated and simmered to allow the ingredients to blend and develop a balanced flavor. After heating, the mixture was cooled and filtered again to achieve a smooth texture. The final product was transferred into clean containers and refrigerated for several hours to produce a chilled beverage. The prepared samples were later subjected to sensory evaluation and phytochemical analysis.

The study employed a developmental and descriptive-experimental research design. The developmental component focused on the formulation and production of the beverage using locally sourced ingredients. The descriptive aspect examined the level of acceptability of the developed product, while the experimental component tested the effects of different bamboo leaf proportions on the sensory qualities and phytochemical properties of the beverage.

The respondents of the study consisted of seventy individuals selected through purposive sampling. These included young adults, adults, middle-aged adults, and experts in food and beverage-related fields. The participation of both consumers and experts allowed the researchers to obtain diverse perspectives regarding the acceptability of the beverage.

Before conducting the evaluation, permission was obtained from the appropriate authorities. The researcher coordinated with local government officials and academic personnel to facilitate the data collection process. Sensory evaluation was conducted among residents of San Guillermo, Isabela, as well as students, faculty members, and staff from Isabela State University–Angadanan Campus. Participants were asked to taste the beverage samples and evaluate them based on color or appearance, odor or aroma, taste or flavor, and smoothness. Standard tasting procedures were followed to ensure reliable results.

The data gathered from the sensory evaluation were carefully organized and analyzed using appropriate statistical methods. One-way analysis of variance was applied to determine whether significant differences existed among the different formulations of the beverage in terms of the evaluated sensory attributes. Descriptive statistics were also used to compare the mean ratings of the samples and identify the formulation that achieved the highest level of acceptability.

On the whole, the methodology enabled the systematic development, evaluation, and analysis of Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan, providing a scientific basis for assessing its sensory quality, bioactive properties, and potential for commercialization.

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RESULTS AND DISCUSSION

Production and product characteristics

The developed Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan was produced through extraction, blending, heating, filtration, bottling, and chilling processes. Bamboo leaves were simmered to obtain a plant extract, which was subsequently combined with pandan leaves, Philippine lime juice, and sugar. The beverage was then filtered and chilled to produce a ready-to-drink herbal tea. Three formulations were prepared using different quantities of bamboo leaves while maintaining constant amounts of the other ingredients. Each formulation consistently produced five 375-ml bottles, demonstrating the reproducibility of the preparation method.

Variations in bamboo leaf quantity influenced the beverage's sensory attributes. Formulations containing higher bamboo leaf concentrations produced darker coloration and stronger herbal aroma, while those with lower concentrations exhibited lighter color and milder aroma. These observations are consistent with earlier studies showing that bamboo leaves contain phenolic compounds, tannins, and flavonoids that influence the color, aroma, and overall sensory characteristics of plant-based infusions (Tongco et al., 2014). Furthermore, the addition of lime and pandan enhanced the beverage's aromatic and flavor complexity, as citrus acids improve freshness while pandan contributes a distinctive fragrance derived from volatile compounds such as 2-acetyl-1-pyrroline (Bhuyan & Sonowal, 2021).

Phytochemical composition and antioxidant activity

Phytochemical screening confirmed the presence of essential oils, flavonoids, tannins, phenols, and anthraquinones across all formulations, while fatty acids and alkaloids were absent. The strong presence of phenolic and flavonoid compounds suggests that the beverage contains significant antioxidant constituents. Previous studies have reported similar phytochemical profiles in bamboo leaves, highlighting the abundance of phenolic compounds responsible for antioxidant, antimicrobial, and anti-inflammatory properties (Cheng et al., 2023). Bamboo leaf extracts have also been shown to possess substantial antioxidant activity due to their flavonoid content (Das, 2019).

Phenolic analysis further demonstrated notable antioxidant potential in the developed beverage. The formulation containing the highest bamboo leaf concentration exhibited the greatest antioxidant activity (224.53 mg AAE/g), followed by the second formulation (197.34 mg AAE/g) and the lowest bamboo leaf formulation (132.02 mg AAE/g). These results indicate that increasing the proportion of bamboo leaves enhances the phenolic concentration and antioxidant capacity of the beverage. Similar findings have been reported in studies showing that bamboo leaf infusions contain significant phenolic compounds and free-radical scavenging activity, supporting their potential use as functional beverages (Indira et al., 2022).

Sensory acceptability

Sensory evaluation revealed a high level of consumer acceptability across all formulations. Mean ratings ranged from 8.03 to 8.53, corresponding to the descriptive categories "Like Very Much" to "Like Extremely Agreeable." These results indicate that the developed beverage achieved favorable sensory qualities in terms of color, aroma, taste, and smoothness.

Among the formulations, the product with the lowest bamboo leaf concentration generally received the highest ratings for taste and smoothness, while the formulation with the highest bamboo leaf concentration obtained the strongest aroma scores. This suggests that moderate bamboo leaf concentrations may produce a more balanced flavor profile for consumer preference. Previous research indicates that the acceptability of herbal beverages is strongly influenced by the balance between herbal intensity and complementary flavoring ingredients (Singhal, 2023). The combination of lime and pandan likely contributed to the positive sensory response because citrus acidity enhances refreshment while pandan provides natural aromatic sweetness (Raman, 2019; Bhuyan & Sonowal, 2021).

Consumer evaluation

The beverage was evaluated by 70 respondents, including young adults, adults, middle-aged adults, and food and beverage experts. Overall ratings across groups ranged from 7.43 to 8.79, indicating consistently favorable evaluations. Adults and middle-aged respondents provided the highest ratings, whereas experts offered slightly more conservative but still positive assessments.

These findings reflect broader consumer trends favoring plant-based functional beverages. Studies have shown that bamboo-derived food products are increasingly recognized for both their nutritional benefits and sensory appeal (Zhang et al., 2024). The presence of natural antioxidants and aromatic compounds further enhances the perceived health value and consumer acceptance of bamboo-based drinks (Nurlila et al., 2024).

Statistical analysis of formulations

Statistical analysis showed no significant difference in overall acceptability among the three formulations ($F = 0.84$, $p = 0.43$). This indicates that variations in bamboo leaf concentration did not significantly affect the overall sensory evaluation of the beverage. However, one formulation showed significant differences among respondent groups ($F = 4.38$, $p = 0.01$), where middle-aged respondents rated the formulation significantly higher than younger respondents and experts.

The absence of significant differences among most formulations suggests that the beverage formulation is relatively stable and widely acceptable across moderate variations in ingredient proportion. Similar observations have been reported in herbal beverage studies, where moderate adjustments in ingredient concentration do not significantly affect consumer acceptance as long as the overall flavor profile remains balanced (Singhal, 2023).

Economic feasibility

The cost analysis showed that each production batch required ₱114.25, yielding five bottles of tea. This corresponds to a production cost of ₱22.85 per bottle. With a 40% markup, the estimated selling price is ₱31.99 per bottle, indicating that the product is economically viable for small-scale production.

The low production cost is partly attributed to the availability of bamboo leaves as an inexpensive raw material. Bamboo is widely recognized as a sustainable plant resource with significant potential for food and beverage applications due to its abundance and rapid growth (Ahmad et al., 2021). Consequently, the developed bamboo leaf tea demonstrates promising potential as a functional beverage with both nutritional and economic value.

CONCLUSION

The findings of the study demonstrate that bamboo leaves can be effectively utilized as a raw material for developing a functional beverage when combined with lime and pandan. The successful production of Bamboo Leaf Refreshing Tea Flavored with Lime and Pandan confirms that the formulation process is feasible and capable of producing a consistent, high-quality product. Phytochemical analysis revealed that the beverage contains beneficial bioactive compounds, particularly flavonoids and phenolic substances, which contribute to its antioxidant properties and functional value. The absence of alkaloids and fatty acids further indicates that the tea is mild and suitable for regular consumption. Sensory evaluation results showed that all formulations achieved high levels of acceptability in terms of color, aroma, taste, and smoothness, with ratings consistently falling within the "Like Very Much" to "Like Extremely Agreeable" range. Statistical analysis revealed no significant difference in overall acceptability among the three formulations, suggesting that the product formulation is stable even with variations in ingredient proportions. However, Formulation 524 emerged as the most consistently preferred formulation, particularly in terms of taste and smoothness. Additionally, cost analysis indicated that the product is economically feasible, as it can be produced at a relatively low cost while maintaining a competitive selling price, making it suitable for small-scale production and potential commercialization.

Based on these findings, several recommendations are proposed to further enhance the development and commercialization potential of the beverage. Formulation 524 should be prioritized in future product development due to its balanced flavor and consistent consumer preference.

Further research should be conducted to determine the shelf life, storage stability, and microbial safety of the product to ensure its quality during distribution and storage. Additional laboratory analyses are also recommended to examine other nutritional components, such as vitamin and mineral content, and to further evaluate its antioxidant properties.

Future improvements may include adjusting the sweetness level or exploring alternative natural sweeteners to meet the preferences of health-conscious consumers. Refinement of ingredient proportions may also be explored to further enhance flavor balance and aroma. Considering bamboo's sustainability as a renewable resource, the use of eco-friendly packaging is recommended to support environmental responsibility and attract environmentally conscious consumers. Moreover, comparative studies with commercial herbal teas may help determine the product's competitive advantages in the market.

Finally, the innovation may be considered for intellectual property protection before commercialization, and the findings should be disseminated through academic publications and presentations to promote further research and development of functional beverages.

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