Utilization of Bamboo *(Bambusa vulgaris)* Shoots in Fresh Pasta Noodle Production

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Abstract

This study aimed to investigate the sensory acceptability of fresh pasta noodles made from bamboo (*Bambusa vulgaris*) shoots, incorporating different proportions at 0% (control), 25%, 50%, 75%, and 100%. The sensory acceptability of the treatments was evaluated in terms of aroma, texture, appearance, and taste, as well as their overall acceptability. The study also analyzed the significant differences in sensory qualities between the experimental treatments and compared them with the control. A completely randomized design was employed, involving sixty (60) evaluators. The results indicated that the inclusion of bamboo shoot in the noodle mixture adversely affected the sensory quality, with these negative effects intensifying at higher bamboo shoot proportions. In terms of aroma, texture, appearance, and taste, the differences among the experimental treatments, with the exception of the control treatment, were not statistically significant. However, significant differences were observed in these sensory aspects when comparing the control treatment to the experimental treatments. In conclusion, the research suggests that even small quantities of high-nutritional-value bamboo shoot flour can negatively impact product quality. Future studies should focus on improving the sensory quality and shelf life of these noodles, while also exploring methods to reduce production costs.

Keywords: Bamboo shoots, *Bambusa vulgaris,* Noodles, Pasta, Sensory evaluation.

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1. Introduction

The COVID-19 pandemic has created food shortages in several nations, causing an increase in flour costs globally, and in effect, some big countries are storing such important supplies. All these occurrences, in addition to the exceptional drought in the world, contribute to a spike in flour prices both at the wholesale and retail levels. It should be noted that, in addition to supply chain interruptions, increasing transportation costs and delivery times have an impact on pricing (Azernews, 2022).

With the inflation going on around the globe, bakers in the Philippines are also striving to keep bread and pastries affordable in the face of rising grain prices. In the report of Ochave (2022), flour costs have risen by 20% to almost 50% in recent months, and flour and wheat supplies seem sufficient in the Philippines. The country is a significant importer of milling-quality wheat due to its lack of agricultural wheat production. Therefore, other alternative elements are worth exploring to help introduce low-cost food production.

Bamboo (*Bambusa vulgaris*) shoot, also known as common bamboo, is a giant tropical and subtropical clumping bamboo native to southern China and Madagascar and is a frequent element in many Asian recipes (Schröder & Link, 2021). Bamboo shoots are regarded as a delicacy for human ingestion (Bisht et al., 2018) and were a popular alternative food source even in the past. It has been reported that bamboo shoots were used in times when no other food sources were available and are considered one of the healthiest foods up to the present because of their low-fat content and high source of dietary fiber (Caasi-Lit et al., 2010; Bisht et al., 2018).

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Bamboo shoots are one of those underutilized elements in food production because bamboo is usually used in building construction, weaponry, musical instruments, and others (Yamini & Suganya, 2021). A team of researchers from Pampanga State Agricultural University has developed various value-adding products using bamboo shoots, such as bamboo shoot pickles, bamboo shoot pies, bamboo shoot oatmeal cookies, bamboo shoot empanada, and bamboo shoot muffins (Zaragoza, 2019), in order to introduce additional uses of the bamboo shoots, especially in the Philippines.

The empirical gap is highlighted in this study. Several studies have suggested that further research on the additional uses of bamboo shoots as a food source may be undertaken. Liu et al. (2018) suggested that new food products from shoots may be developed, including preservation and processing. It has been supported by Maroma (2015) that further study should be conducted to determine the suitability of bamboo shoots in various food products. Also, other suitable varieties of bamboo and unique value-added products out of them can be used (Bhavana et al., 2021). Common bamboo (*Bambusa vulgaris*) will be used in this experiment. It has been commonly used in food-related experimental research in the country (Zaragoza, 2019; Maroma, 2015).

This research aimed to determine the sensory acceptability of pasta noodles utilizing bamboo (*Bambusa vulgaris*) shoot flour. Specifically, it aims to: (1) determine the sensory qualities of bamboo shoot pasta noodles in terms of taste, appearance, texture, and aroma; (2) determine if there is a significant difference among the experimental treatments in terms of taste, appearance, texture, and aroma; and (3) determine if there is a significant difference between the control and the experimental treatments in terms of taste, appearance, texture, and aroma.

2. Literature Review

2.1. Bamboo *(Bambusa vulgaris)* Shoots

The health benefits of bamboo shoots have been scantily understood until recently (Chandramouli & Viswanath, 2015). Bamboo has diverse uses in the culinary field. The utilization of bamboo shoots has gained attention worldwide because of their potential as an alternative plantation crop and their high nutritional value and health benefits. In Behera and Balaji's (2021), they called bamboo shoots "green gold." They described bamboo shoots as magical because of their tremendous health benefits, like anti-cancer, antioxidant, anti-aging, cardio protection, weight loss, and probiotics.

Bamboo shoots are an important economic crop widely cultivated around the world. Because it exhibits potential nutraceutical effects and contains various types of bioactive components, such as carbohydrates, phenols, phytosterols, vitamins, minerals, amino acids, and prebiotic properties, and is a great source of carbon (Chen et al., 2018; Ahmad et al., 2022), it is an excellent source of nutritious food and an incredible way to ensure food security (Singhal et al., 2021).

Xu et al. (2022) reported that bamboo shoots are abundant in dietary fiber and constitute a natural, pollution-free, high-quality food source. Dietary fiber is known to facilitate digestion, provide anti-oxidation benefits, and assist in reducing blood lipid levels. However, an excessive amount of insoluble dietary fiber in bamboo shoots can result in increased lignification and hardness, yielding a coarse taste and excessive residue post-chewing, which substantially diminishes product quality and lowers consumers appeal. Fresh-cut bamboo shoots serve as primary raw materials in the production of ready-to-eat food processing. The quality of these processed foods is closely linked to the dietary fiber content of fresh-cut bamboo shoots.

2.2 Utilization of Bamboo Shoots in Other Studies

Mostly bamboo is utilized as food, the roof and walls of houses, fences, and domestic and agricultural implements such as water containers, food and drink container hats, arrows, and quivers, which has created more opportunities for innovation (Liu et al., 2018; Phimmachanh et al., 2015). Introducing new sources of food, such as bamboo, may be beneficial in addressing the hunger and malnutrition other parts of the world are experiencing (Sharma et al., 2018).

Felisberto et al. (2017) have produced bamboo shoot flour using different varieties such as *Dendrocalamus asper*, *Bambusa tuldoides*, and *Bambusa vulgaris*. The result of their experiment showed that all the bamboo shoots have low moisture content, protein, lipids, and ash contents and therefore can be processed into powder form. In Zhao et al. (2021), they used bamboo shoots as one of the ingredients in a beverage mixed with jujube fruits. The study suggested that the fermentation of red jujube fruits and bamboo shoots could be an effective way to develop a new beverage with high nutritional value, high antioxidant capacity, and high dietary fiber content. Some studies have used bamboo shoots as a fried item, as in the case of Rajchasom et al. (2019),

who were able to introduce a seasoned deep-fried shredded bamboo shoot product. Behera & Balaji (2021) have fermented bamboo shoots and have seen the potential of the product economically, while past studies such as Mustafa et al. (2016) and Bajwa et al. (2018) used bamboo shoot powder to make baked items because of its tremendous health benefits. All these endeavors were rooted in efforts to look for and make use of cheaper sources of food with high nutritional content.

3. Material and Methods

3.1. Materials

The materials and equipment needed in the production process were the following: chopping board, bowls, pots, knife, strainer, tray, measuring spoon, measuring cup, rolling pin, fork, mixing bowl, and knife. All materials and equipment used were clean, thoroughly washed, sterilized, and dried as needed. Bamboo shoots were sourced and purchased from local market vendors in South Cotabato Province, Philippines.

3.2. Production of Bamboo Shoot Flour

Fresh, weighty, firm, and approximately 12-inch-tall shoots were selected for the study. After collecting the bamboo shoots, they were washed thoroughly. The outer leaves and sheaths were removed until they reached the light-colored inner layer. After which, the shots were sliced thinly, washed, boiled for 45 minutes, and drained for at least 10 minutes. After draining, the shoots were sun-dried for 3 days, from 9:00 in the morning until 4:00 in the afternoon. To completely dry the shoots, they were oven-dried for 10 min at 180°C. The dried shoots have been processed in a grinder to pulverize them and sifted out to get a finer texture.

3.3. Production of Bamboo Shoot Fresh Pasta

Ingredients for each treatment were measured, mixed, and kneaded until they became smooth. Then the dough was rested for thirty (30) minutes and covered in cling wrap. The doughs were then rolled to flatten at approximately 1 mm thick, and after flattening the dough, it was cut into strips approximately 3 millimeters wide to make fresh pasta.

3.4. Composition Experimental Treatments and Control

Five treatments shown in Table 1 were used in this experiment, which utilized a Completely Randomized Design (CRD). All treatments will be prepared following the production process, and the ratings will be analyzed using descriptive statistics and a test of difference.

3.5. Sensory Evaluators

A total of sixty respondents were comprised of the sensory evaluators of the study. By including individuals from different backgrounds and experiences, the study aimed to obtain a comprehensive understanding of the acceptability of the treatments under evaluation. The panel of evaluators was composed of students, faculty, and staff of the Joji Ilagan International School of Hotel and Tourism Management, as well as food production professionals and household mothers who were able to provide valuable practical insights.

3.6. Sensory Evaluation Procedures

Prior to the actual conduct of the research, the researchers secured permission from the School Dean of Joji Ilagan International School of Hotel and Tourism Management School Program. The in-charge of the school kitchen laboratory has also permitted the researchers to conduct the sensory evaluation on school premises.

To ensure clarity and prevent any confusion during the study, the researchers utilized small disposable containers for each treatment. Each container is appropriately labeled as Treatment 1, 2, 3, 4, and 5, signifying the different experimental treatments being tested.

Table 1. Experimental Treatments and the Control

Treatment	*Ratio*	*Composition*
T1	100% Bamboo Shoots	2 cups of Bamboo Shoots Flour *+ 3 eggs +1 tablespoon oil + 1 teaspoon salt*
T2	75% Bamboo Shoots; 25% All Purpose Flour	1½ cup Bamboo Shoots Flour + ½ cup of All Purpose Flour *+ 3 eggs +1 tablespoon oil + 1 teaspoon salt*
T3	50% Bamboo Shoots; 50% All Purpose Flour	1 cup Bamboo Shoots Flour + 1 cup of All Purpose Flour *+ 3 eggs +1 tablespoon oil + 1 teaspoon salt*
T4	25% Bamboo Shoots; 75% All Purpose Flour	½ cup Bamboo Shoots Flour + 1½ cup of All Purpose Flour *+ 3 eggs +1 tablespoon oil + 1 teaspoon salt*
T5 (Control)	100% All Purpose Flour	2 cups of All Purpose Flour *+ 3 eggs +1 tablespoon oil + 1 teaspoon salt*

For the evaluation of each treatment, evaluators were tasked with sequentially tasting them. To eliminate any lingering aftertaste from the previous treatment and to effectively distinguish between the various treatments, participants were provided with water to drink. This process was designed to guarantee accurate results by minimizing any potential carryover effects.

To facilitate the assessment process, researchers provided participants with evaluation forms and detailed instructions. The collected survey results were then checked for completeness and compiled for data analysis.

The sensory acceptability of the treatments was assessed using a 5-point hedonic scale. This scale allows participants to provide their responses based on their preferences, ranging from disliked very much (1.0–1.49) to liked very much (4.5–5.0).

3.7. Data Analysis

Once the survey forms had been gathered, the research team proceeded with the task of systematically organizing and summarizing the collected data for comprehensive analysis. The data were carefully compiled and processed statistically. Weighted means were employed to effectively describe the acceptability of each treatment, as well as the overall acceptability of all treatments.

To analyze the significant distinctions between the control group and the experimental treatments, pertaining to aroma, texture, appearance, and taste, an Analysis of Variance (ANOVA) was conducted. This statistical technique facilitates a comprehensive investigation into the variations in sensory characteristics between the control and experimental groups. By employing ANOVA, the researchers were able to determine if any statistically significant differences existed. To explore potential significant differences among the experimental treatments in relation to crucial sensory attributes such as aroma, texture, appearance, and taste, the researchers employed a Z-Test.

3.8. Ethical Considerations

Before proceeding with the sensory evaluation, the researcher ensured that all respondents were given the consent form. This form contained comprehensive information about the study, including its aims, limitations, benefits, and institutional approval. Additionally, participants were assured that their personal data has been treated confidentially, and they will have the freedom to discontinue their survey participation at any time and for any reason. Furthermore, the researchers have emphasized that participation should be voluntary. The evaluators were informed of the contents of the treatments and any health concerns that may arise from consuming the product.

4. Results and Discussion

4.1. Acceptability of the Experimental Treatments and the Control

Table 2 provides information about the general acceptability of bamboo shoot pasta noodles. The table includes ratings for various experimental treatments, as well as a control treatment (treatment 5). According to the data, all experimental treatments were rated slightly acceptable, indicating that they were generally slightly accepted by the participants or evaluators.

Table 2. Acceptability of the Experimental Treatments and the Control in Terms of the Sensory Qualities

Treatment	*Aroma*		*Texture*		*Appearance*		*Taste*	
	Mean	*Interpretation*	*Mean*	*Interpretation*	*Mean*	*Interpretation*	*Mean*	Interpretation
T1	1.83	Slightly Acceptable	1.75	Slightly Acceptable	1.75	Slightly Acceptable	1.83	Slightly Acceptable
T2	1.95	Slightly Acceptable	1.95	Slightly Acceptable	1.95	Slightly Acceptable	1.92	Slightly Acceptable
T3	2.47	Slightly Acceptable	2.37	Slightly Acceptable	2.48	Slightly Acceptable	2.42	Slightly Acceptable
T4	2.92	Moderately Acceptable	2.80	Moderately Acceptable	2.88	Slightly Acceptable	3.12	Acceptable
T5 (Control)	3.45	Moderately Acceptable	3.47	Acceptable	3.60	Acceptable	3.55	Acceptable

Legend: 4.5 – 5.0 = Highly Acceptable; 3.5 – 4.49 = Acceptable; 2.5 – 3.49 = Moderately Acceptable; 1.5 – 2.49 = Slightly Acceptable; 1.0 – 1.49 = Not Acceptable

However, the control treatment (treatment 5) received a moderately acceptable rating. The data focuses on evaluating the table further and points out that treatment 4 obtained the highest acceptability rate among all the experimental treatments. This implies that treatment 4 was considered the most acceptable option among the tested variations of bamboo shoot pasta noodles. As a result, the data suggests that treatment 4 could be recommended as the preferred option, presumably for further development or adoption.

4.2 The Significant Difference among the Experimental Treatments in Terms of Aroma, Texture, Appearance, and Taste

Table 3 shows if there is a significant difference among the experimental treatments. The p-values for aroma, texture, appearance, and taste (p=0.00) are less than the significance level (p<0.05). This means that there is a significant difference among the experimental treatments in terms of all their sensory qualities. Therefore, there is sufficient evidence at a significance level (p<0.05) that the treatments are significantly different from each other.

4.3. The Significant Difference Between the Control and the Experimental Treatments in Terms of Taste, Appearance, Texture, and Aroma

Table 4 presents the significant difference between the control and the experimental treatments in terms of taste, appearance, texture, and aroma. In terms of aroma, the z-values for pair 1, pair 2, pair 3, and pair 4 are -11.83, -11.45, -7.62, and -4.07, respectively. The z-tabular value, which represents the critical value at a specific level of significance, is 1.96 at the 0.05 level. Comparing the z-values to the z-tabular value, it is observed that the z-values are all lower than the z-tabular value. This indicates that there is no significant difference between the treatments and the control for aroma. Similarly, for texture, the z-values for the different pairs are -12.51, -12.18, -8.93, and -5.41. The z-tabular value is 1.96 at the 0.05 level. As with the aroma, all the z-values for texture are lower than the z-tabular value, suggesting no significant difference between treatment and control in terms of texture. In terms of appearance, the z-values for the pairs are -13.73, -13.11, -9.55, and -6.17. All the z-values for appearance are lower than the z-tabular value, indicating no significant difference between treatment

Table 3. Analysis of Variance (ANOVA) on the Difference in the Acceptability of Sensory Qualities among Experimental Treatments

Aroma						
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	44.88	3	14.96	24.74	0.00	2.64
Within Groups	142.70	236	0.60			
Total	187.58	239				
Texture						
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	39.10	3	13.03	26.15	0.00	2.64
Within Groups	117.63	236	0.50			
Total	156.73	239				
Appearance						
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	47.67	3	15.89	26.93	0.00	2.64
Within Groups	139.27	236	0.59			
Total	186.93	239				
Taste						
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	62.61	3	20.87	34.28	0.00	2.64
Within Groups	143.68	236	0.61			
Total	206.30	239				

There is a significant difference if p-value < 0.05.

and control regarding appearance. In terms of taste, the z-values for the pairs are -12.74, -13.41, -9.47, and -3.37. All the z-values for taste are below the z-tabular value, signifying no significant difference between treatment and control in terms of taste. In summary, based on the comparison of the z-values to the z-tabular value, it can be concluded that there is no significant difference between the treatments and the control for any of the variables: aroma, texture, appearance, and taste.

Table 4. Z-test on the between the Control and Experimental Treatments in Terms of Aroma, Texture, Appearance, and Taste

Sensory Qualities	*Treatments*	*Means*	*P(Z<=z) two-tail*
Aroma	T1	1.83	0.00
	T5	3.45	
	T2	1.95	0.00
	T5	3.45	
	T3	2.47	0.00
	T5	3.45	
	T4	2.92	0.00
	T5	3.45	
Texture	T1	1.75	0.00
	T5	3.47	
	T2	1.95	0.00
	T5	3.47	
	T3	2.37	0.00
	T5	3.47	
	T4	2.80	0.00
	T5	3.47	
Appearance	T1	1.75	0.00
	T5	3.60	
	T2	1.95	0.00
	T5	3.60	
	T3	2.48	0.00
	T5	3.60	
	T4	2.88	0.00
	T5	3.60	
Taste	T1	1.85	0.00
	T5	3.55	
	T2	1.92	0.00
	T5	3.55	
	T3	2.42	0.00
	T5	3.55	
	T4	3.12	0.00
	T5	3.55	

5. Conclusions

The results of the evaluation of the sensory qualities of bamboo shoot pasta showed fair acceptance or moderate dislike by the evaluators. This means that utilizing bamboo shoots in producing fresh pasta is generally moderately disliked; therefore, other formulations may be developed to determine the most acceptable treatment. As observed in Treatment 4, which contains the least proportion of bamboo powder, the result is still moderately disliked. This implies that even though bamboo shoots have huge potential as a food source (Bisht et al., 2018; Schröder & Link, 2021; Zaragoza, 2019), their flour form cannot be used in higher proportions or as a complete substitute for flour. The results support the observations of Vanlallani and Dhiman (2020) that a minimal proportion of bamboo shoot flour may be acceptable and may improve wheat-flour-based products' sensory quality but not exceed 6 percent of the formulation. This makes it more consistent with other results of the study, such as Santosh et al. (2018), who found that adding bamboo shoot flour to bakery products showed poor acceptability of the sensory qualities. This means that the higher the proportion of bamboo shoot flour to wheat-based flour in bakery products, the more likely it is to be unacceptable.

6. Implications

6.1. Implications to Culinary Practice

As presented in the results, the researchers recommend not completely using bamboo shoot flour as a substitute for wheat flour since bamboo shoot flour has a distinct taste and flavor that may not be desirable or compatible with certain recipes. It could alter the taste of baked goods and may not be suitable for all culinary applications. The researchers recommend the use of another technique for drying bamboo shoots to potentially enhance the flavor, texture, and overall quality of dried bamboo shoots. Treatment 4 may be used in kitchen preparations to produce bamboo shoot pasta. The ratio of bamboo shoot flour to all-purpose flour may be modified.

6.2. Implications to Research

Future researchers are recommended to identify the shelf life of bamboo shoot pasta. A lesser number of food production professionals and chefs participated in the sensory evaluation; therefore, it is suggested that a similar study be conducted with larger participants from this sector. Future researchers may conduct a cost-return analysis of bamboo shoot pasta noodles

and the control treatment to identify the potential economic return of the product.

Declaration of Competing Interest

The author declare that they have no financial or non-financial competing interests.

Author's Contributions

A.M. Ibrahim (0000-0002-8010-4533): *Conceptualization, Methodology, Data Analysis, Editing, Supervision, Investigation*.
J. P. Dalupan, J. M. Dongosa, G.M. Bretaña, and R.J.S. Cajulao: *Data Collection, Investigation, Conceptualization, Writing, Methodology*.

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