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Physicochemical and Sensory Properties of Bougainvillea-Flavored Sponge Cake using Extract, Powder, Dried, and Fresh forms

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ABSTRACT: This study evaluated the physicochemical and sensory properties of sponge cakes incorporated with Bougainvillea (Bougainvillea spectabilis) in four forms: extract, powder, dried, and fresh. Parameters such as moisture content, pH, color, texture, and overall acceptability were measured. Among the forms, the powdered Bougainvillea sample yielded the highest sensory acceptability, while the extract-treated cakes showed the most favorable physicochemical stability. The findings suggest potential functional and aesthetic applications of Bougainvillea in cake formulation.

KEYWORDS: Bougainvillea, sponge cake, physicochemical properties, sensory evaluation, food innovation

I. INTRODUCTION

In the expanding realm of functional foods and culinary innovation, edible flowers have emerged as attractive ingredients for their aesthetic and nutritional contributions. Among these, Bougainvillea spectabilis—a vibrant ornamental plant known for its papery bracts—has garnered attention for its potential in food applications due to its phytochemical profile, which includes phenolics, flavonoids, and betalains (Gupta et al., 2021). While traditionally used in herbal medicine for treating cough, sore throat, and digestive issues, Bougainvillea has recently been explored as a source of antioxidants and natural colorants (Rathi et al., 2022). However, its incorporation into bakery products, particularly sponge cakes, remains under-researched.

Sponge cake is a widely consumed bakery item prized for its soft, airy texture and adaptability to various flavors. It is an ideal matrix for testing novel ingredients due to its relatively neutral taste and simple formulation (Saxena & Meena, 2020). Adding plant-based ingredients to sponge cake has been a popular strategy to enhance the nutritional and functional value of baked products. For example, integrating moringa leaf powder, hibiscus extract, and even vegetable purees into cakes has demonstrated improved antioxidant content and favorable consumer responses (Patel et al., 2021). Inspired by such studies, the current research aims to explore the potential of Bougainvillea in sponge cake as a natural flavor enhancer and functional ingredient.

The form in which plant ingredients are introduced into a recipe often influences their effectiveness and acceptability. Drying and powdering can concentrate bioactive compounds and extend shelf life; however, the loss of volatile aroma compounds during heat processing may impact flavor perception (Yuan et al., 2020). On the other hand, using fresh or extracted forms may retain aromatic integrity but compromise texture or water activity in baked goods. Therefore, comparing the impact of different Bougainvillea preparations—extract, powder, dried petals, and fresh petals—on the sensory and physicochemical properties of sponge cake is essential to determine the optimal form for product development.

This study thus aims to investigate the effects of these four Bougainvillea forms on sponge cake quality, focusing on moisture content, pH, color, texture, and sensory acceptability. Through this work, we aim to develop a practical and appealing method for incorporating Bougainvillea into baked goods, thereby contributing to the growing movement of floral gastronomy and functional baking. The research also aims to fill a knowledge gap in edible flower utilization by providing empirical data on a novel application of Bougainvillea in a commonly consumed food product.

II. METHODOLOGY

This chapter presents the research methodologies employed in conducting the study. It includes the research design, locale, study population, materials used, data collection procedure, and data analysis techniques employed to evaluate the physicochemical and sensory properties of sponge cakes with Bougainvillea in various forms.

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Research Design

This study employed a descriptive-comparative research design, which enabled the systematic evaluation and comparison of four treatments of sponge cake incorporating Bougainvillea spectabilis in various forms: extract, powder, dried petals, and fresh petals. The design enabled researchers to examine the differences in physicochemical properties and sensory characteristics of the treatments. A panel of consumers evaluated the sensory properties using a hedonic rating scale, while the physicochemical attributes were measured using standard laboratory methods.

Locale and Population of the Study

The research was conducted at the Senior High School Home Economics Laboratory of Gayong-gayong Sur Integrated School, where facilities for baking and fundamental food analysis were available. A total of 30 untrained panelists, composed of students and faculty members aged 18–50, were selected through purposive sampling to participate in the sensory evaluation. All participants were screened to ensure that they had no food allergies or aversions to floral flavors.

Materials and Ingredients

Fresh Bougainvillea flowers were sourced from organically maintained home gardens in Quezon City. Four types of Bougainvillea treatments were prepared:

- **Extract** – Petals boiled in water (10g petals per 100 mL), filtered, and cooled.
- **Powder** – Oven-dried petals at 60°C for 24 hours, then ground finely.
- **Dried** – Oven-dried whole petals at 60°C.
- **Fresh** – Washed, chopped petals.

Each treatment was incorporated at a concentration of 5% (w/w) based on the total flour weight into a standard sponge cake formulation, which included flour, eggs, sugar, butter, and baking powder. The control group was a plain sponge cake with no Bougainvillea added.

Data Gathering Procedure

The cakes were prepared using a standardized method and baked at 180°C for 30 minutes. Once cooled, they were cut into equal portions and labeled anonymously to prevent bias. Each panelist was asked to evaluate all four variants randomly to avoid order effects.

Physicochemical analyses included:

- **Moisture content** (oven drying method at 105°C),
- **pH** (digital pH meter),
- **Color** (L*, a*, b* values using a chromameter),
- **Texture** (hardness measured using a texture analyzer).

Sensory evaluation was conducted using a 9-point hedonic scale to assess attributes such as color, aroma, taste, texture, and overall acceptability.

Treatment of Data

The data collected were statistically analyzed using the following tools:

1. **Weighted Mean** – To summarize the sensory ratings for each cake variant.
2. **One-Way ANOVA** – To determine significant sensory and physicochemical properties differences across the four treatments.
3. **Tukey's HSD Post Hoc Test** – To identify specific group differences where applicable.

All statistical analyses were performed using SPSS software, with significance at $p < 0.05$.

III. RESULTS AND DISCUSSION

This chapter presents and interprets the data collected on the physicochemical and sensory evaluation of sponge cakes made with Bougainvillea in four forms: extract, powder, dried petals, and fresh petals. The discussion includes an analysis of texture, taste, aroma, appearance, color, pH, moisture, and acceptability, as evaluated by the respondents and measured using instrumental methods.

3.1. Physicochemical Properties of Bougainvillea-Flavored Sponge Cakes

Table 1 presents the measured physicochemical properties of the four treatments. The fresh Bougainvillea sample had the highest moisture content (27.4%), primarily due to the natural water content of the petals. The powdered and dried forms exhibited significantly lower moisture levels (22.1% and 23.5%, respectively), indicating improved stability and a reduced risk of microbial spoilage. Cakes with Bougainvillea extract recorded an intermediate moisture content of 25.6%.

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The pH values of the sponge cakes ranged from 6.40 to 6.58. The extract treatment had the lowest pH, indicating slight acidity, which may be attributed to the water-soluble organic acids in the floral infusion. All values remained within the normal pH range for sponge cakes and did not adversely affect palatability.

Table 1 also shows the color readings based on L*, a*, and b* values. The powdered Bougainvillea sample exhibited the most intense red hue (a* = 13.5), suggesting enhanced pigment retention during drying. The fresh and extract forms had more muted a* values, while dried petals led to less consistent coloring due to uneven dispersion. Lightness (L*) values were highest in the extract (L* = 72.1) and lowest in the powder (L* = 65.3), indicating a deeper color in the latter.

Texture analysis revealed that sponge cakes with powdered Bougainvillea had the softest crumb (hardness = 3.6 N), followed by those with extract (4.1 N), fresh (4.9 N), and dried (5.3 N) ingredients.

Table 1: Physicochemical Properties of Bougainvillea Sponge Cake

Treatment	Moisture (%)	pH	L*	a*	Hardness (N)
Extract	25.6	6.40	72.1	10.2	4.1
Powder	22.1	6.58	65.3	13.5	3.6
Dried	23.5	6.52	68.4	9.8	5.3
Fresh	27.4	6.48	70.2	11.1	4.9

3.2. Sensory Evaluation of Bougainvillea-Flavored Sponge Cakes

Table 2 summarizes the sensory ratings for each treatment based on responses from 30 untrained panelists.

Appearance received the highest mean score in the powdered treatment (8.2), attributed to the even distribution and intensified coloration. Cakes with fresh Bougainvillea were visually appealing but inconsistent in appearance due to petal oxidation and moisture pockets.

Aroma was rated highest in the extract and powder treatments (7.6 and 7.4, respectively), owing to better retention of floral volatiles. Dried and fresh treatments received lower aroma ratings due to degradation of scent compounds during oven drying or baking.

Taste was also preferred in the powdered Bougainvillea cake (mean score = 8.1), followed by extract (7.7). Fresh and dried forms received lower scores due to either bitterness or lack of integration with the cake flavor profile.

As consumers perceived, texture was favored in the powdered and extract samples (7.8 and 7.5, respectively), consistent with instrumental analysis. Dried petals created a coarse texture, while fresh petals made the crumb slightly gummy.

Overall Acceptability ranked the treatments as follows:

1. Powder – 8.0
2. Extract – 7.6
3. Dried – 6.8
4. Fresh – 6.4

Table 2: Sensory Evaluation of Bougainvillea Sponge Cake

Treatment	Appearance	Aroma	Taste	Texture	Overall Acceptability
Extract	7.9	7.6	7.7	7.5	7.6
Powder	8.2	7.4	8.1	7.8	8.0
Dried	6.9	6.6	6.7	6.6	6.8
Fresh	7.1	6.2	6.4	6.3	6.4

3.3. Statistical Analysis

ANOVA revealed significant differences ($p < 0.05$) among treatments for color, taste, and texture attributes. Post-hoc Tukey's HSD test confirmed that the powdered treatment was significantly more preferred in taste and appearance than the fresh and dried forms. However, no significant difference was observed between the powder and extract treatments for overall acceptability, indicating both are viable options for commercial use.

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

The study demonstrated that incorporating Bougainvillea into sponge cake significantly influences both its physicochemical and sensory characteristics among the four forms tested—extract, powder, dried, and fresh. The powdered Bougainvillea treatment

yielded the most favorable results in terms of sensory acceptability, particularly in appearance, taste, texture, and overall preference. It also contributed to a rich color and soft texture without compromising moisture or pH stability. The extract form followed closely, offering desirable physicochemical traits and maintaining a balanced sensory profile. Conversely, the dried and fresh forms were less preferred due to issues related to inconsistent appearance, coarser or gummy texture, and weaker flavor integration.

These findings suggest that Bougainvillea has strong potential as a novel functional and aesthetic ingredient in baked products, especially in its powdered form. This research provides empirical support for the innovative use of edible flowers in bakery applications, contributing valuable data to the growing field of floral gastronomy and functional foods.

RECOMMENDATIONS

1. Commercial Application: Due to its high acceptability and shelf-stability, food product developers are encouraged to explore powdered Bougainvillea as a viable natural additive in cake and pastry formulations.
2. Shelf-Life Studies: Future studies should evaluate the shelf life and microbial stability of Bougainvillea-enhanced cakes, particularly for powder and extract forms.
3. Phytochemical Analysis: To quantify the nutritional benefits of each form, a detailed chemical analysis of the antioxidant, flavonoid, and phenolic content should be conducted.
4. Broader Consumer Testing: Expanding sensory evaluations to a broader demographic may yield more comprehensive data on market acceptability.
5. Product Variants: Investigating the effects of Bougainvillea on other bakery items (e.g., muffins, cookies, or bread) could further broaden its commercial potential.

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