



Premix Based on Taro Flour (*Colocasia esculenta*) with the Addition of Breadfruit Flour (*Artocarpus altilis*)

Putri Permata Sari*, Asri Widyasanti

Universitas Padjadjaran

*Correspondence: Putri Permata Sari
Email: putrisari0313@gmail.com

Received: 11-12-2025
Accepted: 11-01-2026
Published: 11-02-2026



Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

Abstract: This study aimed to obtain the optimal formulation of a gluten-free waffle premix based on taro flour (*Colocasia esculenta*) with the addition of breadfruit flour (*Artocarpus altilis*) and to evaluate its physicochemical characteristics and consumer acceptance. The research was conducted using a Completely Randomized Design with a single factor, consisting of four formulation ratios of taro flour to breadfruit flour, namely 100:0, 75:25, 50:50, and 25:75, with three replications for each treatment. Physicochemical analyses were performed on the waffle premix, including moisture content using the oven-drying method, particle fineness through sieve analysis and fineness modulus determination, and color measurement using a colorimeter based on the CIELAB system (L^* , a^* , b^*). Sensory evaluation was carried out through a hedonic test using untrained panelists to assess color, aroma, taste, texture, and overall acceptance of the resulting waffles. The results showed that differences in flour formulation significantly affected moisture content, particle fineness, and color characteristics of the gluten-free waffle premix ($p < 0.05$). Moisture content values of all formulations were below the maximum standard for flour-based products, indicating good storage stability. Increasing the proportion of breadfruit flour tended to reduce brightness (L^*) and increase yellowness (b^*). Based on hedonic test results, the formulation with an equal ratio of taro flour and breadfruit flour (50:50) obtained the highest scores for taste, texture, and overall acceptance. These results indicate that the 50:50 formulation represents the optimal gluten-free waffle premix and has potential for further development as a locally based functional food product.

Keywords: Gluten-Free Waffle Premix, Taro Flour, Breadfruit Flour, Physicochemical Properties, Hedonic Test

Introduction

The rapid growth of gluten-free food consumption has intensified research on alternative flours derived from local crops to replace wheat flour, particularly in countries that rely heavily on wheat imports. In Indonesia, the utilization of indigenous carbohydrate sources such as taro (*Colocasia esculenta*) and breadfruit (*Artocarpus altilis*) is considered a strategic approach to support food diversification and sustainable agro-industrial development (Kusumawati et al, 2021). Taro flour is known for its high starch content, low fat level, and favorable water-binding capacity, making it suitable for gluten-free formulations (Sepno, 2021). Breadfruit flour, on the other hand, contributes dietary fiber and

distinctive sensory characteristics that may enhance product acceptability (Wulandari et al, 2019).

Previous studies have explored the application of taro and breadfruit flour in various gluten-free products, such as biscuits, cookies, and composite flour formulations (Ismail et al, 2023) (Ginting et al, 2020) (Sabatini et al, 2021). However, research specifically addressing the development of gluten-free waffle premix products remains limited. Most existing studies focus on ready-to-eat products, while investigations on premix formulations—which offer advantages in terms of practicality, consistency, and shelf stability—are still scarce. Moreover, the absence of gluten poses technological challenges in achieving desirable texture and structural integrity in waffle products, necessitating optimization of flour composition.

Therefore, this study aimed to evaluate the effect of varying ratios of taro flour and breadfruit flour on the physicochemical characteristics and consumer acceptance of a gluten-free waffle premix. The significance of this research lies in providing scientific evidence for the optimal formulation of a locally based gluten-free waffle premix with acceptable quality attributes. The findings are expected to contribute to the development of value-added food products utilizing local resources, support food diversification programs, and serve as a reference for further research and commercialization of gluten-free premix products in Indonesia.

Research Method

This study was carried out from October to December 2025 at the Postharvest and Process Technology Laboratory, Faculty of Agricultural Industrial Technology, Universitas Padjadjaran, Indonesia. The experimental design employed was a Completely Randomized Design with a single factor, namely the ratio of taro flour to breadfruit flour, consisting of four treatments (100:0, 75:25, 50:50, and 25:75) and three replications. The gluten-free waffle premix samples were prepared using standardized formulations to ensure consistency across treatments.

Data collection involved physicochemical and sensory evaluations. Physicochemical properties were assessed by measuring moisture content using the oven-drying method, particle fineness through sieve analysis and fineness modulus calculation, and color characteristics using a colorimeter with CIELAB parameters (L^* , a^* , b^*). Sensory data were obtained through a hedonic test conducted by untrained panelists to evaluate color, aroma, taste, texture, and overall acceptance using a five-point scale. The collected data were statistically analyzed using one-way ANOVA at a 5% significance level to identify significant differences among formulations. The results were interpreted based on statistical outcomes and descriptive trends to ensure data validity, reliability, and reproducibility.

Result and Discussion

Pre-Market Survey Analysis

A pre-market survey was conducted prior to product formulation to assess consumer characteristics, awareness, and acceptance potential of gluten-free waffle premix products. The survey involved 32 respondents selected using convenience sampling, targeting adolescents and adults who regularly consume bakery products and represent potential consumers of gluten-free foods. The collected data covered demographic characteristics, product awareness, perceived importance of gluten-free foods, and willingness to try the proposed product.

Table 1. Respondent Criteria and Data Collection Characteristics

Criteria	Description
Number of respondents	32 participants
Age range	Adolescents to adults (17–45 years)
Gender composition	Dominated by female respondents
Sampling method	Convenience sampling
Data collection method	Online questionnaire (Google Form)
Awareness of gluten-free waffle premix	Approximately 50% of respondents
Perceived importance of gluten-free foods	81.8% rated as important to very important
Willingness to try the product	66.7% willing or possibly willing

The dominance of female respondents is relevant, as women commonly play a significant role in household food purchasing decisions. In addition, the high proportion of respondents perceiving gluten-free products as important indicates increasing awareness of healthier food alternatives. Although product familiarity remains moderate, the willingness to try the gluten-free waffle premix suggests a favorable market opportunity, particularly if sensory quality and product communication are optimized.

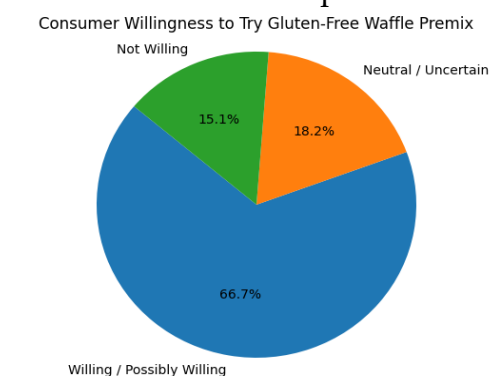


Figure 1. Consumer Willingness to Try Gluten-Free Waffle Premix

66.7%: Willing or possibly willing
18.2%: Neutral or uncertain
15.1%: Not willing

The pie chart illustrates that more than two-thirds of respondents show a positive inclination toward trying the product, confirming its potential acceptance in the target market. These findings support the feasibility of further product development and sensory optimization prior to commercialization.

Formulation Characteristics of Gluten-Free Waffle Premix

Four gluten-free waffle premix formulations were prepared using different ratios of taro flour and breadfruit flour, namely 100:0, 75:25, 50:50, and 25:75. The formulation process was conducted through dry blending of all dry ingredients to ensure homogeneity and to minimize moisture uptake, which is essential for extending product shelf life. Taro flour functioned as the primary starch source, while breadfruit flour acted as a complementary ingredient contributing dietary fiber and characteristic sensory attributes.

The absence of gluten required careful adjustment of flour ratios to maintain acceptable dough structure and functional properties. Variations in flour composition were expected to influence physicochemical characteristics, particularly moisture retention, particle size distribution, and color attributes. The formulation containing equal proportions of taro and breadfruit flour was hypothesized to provide a balanced interaction between starch functionality and sensory enhancement.

Moisture Content Analysis

Moisture content analysis was conducted using the oven-drying method, in which premix samples were dried at a controlled temperature until constant weight was achieved. This method is widely applied to evaluate the stability and shelf-life potential of flour-based products. The moisture content of all formulations ranged from approximately 6% to 9%, indicating compliance with general quality standards for premix and flour products.

Statistical analysis using one-way ANOVA showed that differences in flour formulation significantly affected moisture content ($p < 0.05$). Formulations with higher proportions of breadfruit flour tended to exhibit lower moisture content, which may be attributed to differences in starch structure and water-binding capacity between taro and breadfruit flour. Lower moisture levels are advantageous because they reduce microbial growth and slow physicochemical deterioration during storage. These results are consistent with previous studies reporting that reduced moisture content contributes to improved shelf stability of gluten-free premix products.

Particle Fineness Distribution

Particle fineness was evaluated through sieve analysis, followed by fineness modulus calculation to quantify average particle size distribution. This analysis was performed to assess flour homogeneity, which directly affects dough hydration and mixing behavior. The results indicated variations in fineness modulus among formulations, reflecting differences in particle size distribution caused by flour composition.

Formulations with balanced ratios of taro and breadfruit flour exhibited more uniform particle size distribution, which is favorable for consistent mixing and dough formation. In contrast, formulations with a higher proportion of a single flour tended to show either excessively coarse or overly fine particles. Excessively coarse particles may cause uneven hydration, while overly fine particles can increase water absorption and negatively affect dough handling. The 50:50 formulation demonstrated an optimal balance between fine and coarse fractions, resulting in improved dough workability and structural uniformity, supporting the functional advantage of composite flour formulations.

Color Characteristics

Color characteristics of the gluten-free waffle premix were measured using a colorimeter based on the CIELAB color system, which provides objective values for brightness (L^*), redness (a^*), and yellowness (b^*). The analysis showed that increasing the proportion of breadfruit flour resulted in a decrease in brightness (L^*) and an increase in yellowness (b^*), indicating a darker and more yellowish appearance.

These changes are likely associated with the presence of natural pigments in breadfruit flour and possible non-enzymatic browning reactions occurring during processing. Although darker color may reduce visual appeal for certain consumers, moderate color intensity is often perceived as a natural characteristic of whole-food-based products. The formulation with a 50:50 ratio maintained relatively high brightness while displaying a mild creamy-yellow color, which was considered visually acceptable by panelists. This suggests that balanced flour composition can preserve desirable color attributes while enhancing product functionality.

Conclusion

The formulation of gluten-free waffle premix based on taro flour with the addition of breadfruit flour was shown to significantly influence both physicochemical and sensory characteristics of the product ($p < 0.05$). Moisture content across all formulations ranged from approximately 6.38% to 8.37%, remaining below the maximum moisture limit for flour-based products and indicating good storage stability. Particle fineness analysis demonstrated that the 50:50 taro-to-breadfruit flour ratio provided the most uniform particle size distribution, which is essential for dough homogeneity and processing performance. Color evaluation using the CIELAB system revealed that this formulation maintained relatively high brightness values while exhibiting acceptable yellowness, contributing to favorable visual quality. Sensory evaluation further confirmed that the 50:50 formulation achieved the highest hedonic scores for taste, texture, and overall acceptance, indicating strong consumer preference.

These findings highlight the practical potential of composite flour formulation in overcoming structural limitations commonly associated with gluten-free bakery products. The utilization of locally sourced taro and breadfruit flour not only improves product quality but also supports food diversification strategies and reduces dependence on imported wheat flour in Indonesia. For practical application, the 50:50 formulation is

recommended as a promising gluten-free waffle premix for small- to medium-scale food industries. Future research is suggested to evaluate shelf-life stability, nutritional composition, and economic feasibility, as well as the incorporation of natural binding agents or hydrocolloids to further enhance texture and product consistency.

References

- Ahmed, J., Almusallam, A. S., & Al-Salman, F. (2022). Impact of thermal processing on color and physicochemical properties of starch-based flour products. *Journal of Food Processing and Preservation*, 46(3), e16241.
- AOAC. (2019). *Official methods of analysis* (21st ed.). Association of Official Analytical Chemists.
- Biesiekierski, J. R. (2017). What is gluten? *Journal of Gastroenterology and Hepatology*, 32(Suppl. 1), 78–81.
- Cao, X., Zhang, Y., Wang, L., & Chen, Z. (2021). Particle size distribution and functional properties of composite flours. *Food Chemistry*, 343, 128476.
- Ginting, E., Antarlina, S. S., & Widowati, S. (2020). Formulation of breadfruit flour-based food products for gluten-free applications. *Journal of Food Science and Nutrition*, 8(4), 1763–1771.
- Herlina, N., Sari, D. R., & Putra, A. (2020). Moisture content and shelf-life stability of flour-based products. *Indonesian Journal of Food Technology*, 3(2), 89–96.
- Ismail, R., Hasanah, U., & Putri, R. M. (2023). Effect of taro flour substitution on chemical and sensory properties of gluten-free biscuits. *International Journal of Food Studies*, 12(1), 45–56.
- Kaur, A., & Singh, N. (2020). Particle size and hydration properties of gluten-free flours. *Food Chemistry*, 305, 125456.
- Ktenioudaki, A., Chaurin, V., & Gallagher, E. (2019). Role of salt in gluten-free bakery products. *Journal of Cereal Science*, 85, 102–109.
- Kusumawati, D., Prasetyo, E., & Nugraha, A. (2021). Local food diversification to reduce wheat dependency in Indonesia. *Journal of Agroindustrial Technology*, 31(2), 123–134.
- Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: Principles and practices* (2nd ed.). Springer.
- Lee, J. H., Kim, M. J., & Park, J. S. (2021). Effects of leavening agents on gluten-free bakery products. *Food Research International*, 140, 109862.
- Liu, X., Zhang, Y., & Wang, L. (2021). Color stability of root-based flour during processing. *LWT – Food Science and Technology*, 150, 111902.
- Mane, A., Patil, S., & Kulkarni, S. (2022). Moisture control and storage stability of instant food premixes. *Journal of Food Safety*, 42(4), e13012.
- Martínez-Anaya, M. A. (2020). Fermentation processes in bakery products. *Food Microbiology*, 89, 103451.

- Meilgaard, M., Civille, G. V., & Carr, B. T. (2016). *Sensory evaluation techniques* (5th ed.). CRC Press.
- Pradana, A., & Rahayu, W. P. (2020). Development of gluten-free products from tuber flours. *Journal of Food and Nutrition Research*, 8(9), 482–490.
- Rosell, C. M., Barro, F., Sousa, C., & Mena, M. C. (2019). Cereals for developing gluten-free products and analytical tools for gluten detection. *Trends in Food Science & Technology*, 83, 28–38.
- Rosida, D. F., Hapsari, N., & Wijaya, R. (2018). Effect of particle size on dough characteristics and baked product quality. *Journal of Food Processing and Preservation*, 42(7), e13655.
- Sabatini, S., Renzetti, S., & Arendt, E. K. (2021). Composite flour formulations for gluten-free dough systems. *Journal of Cereal Science*, 99, 103196.
- Sepno, A. (2021). Physicochemical characteristics of taro flour as wheat flour substitute. *Journal of Tropical Food Science*, 4(1), 12–20.
- Statista. (2024). Waffle and wafer market growth in Indonesia. Statista Research Department.
- Widodo, S., Pratiwi, R., & Nugraha, A. (2023). Moisture stability of gluten-free premix products. *International Journal of Food Science*, 2023, 1–9.
- Wulandari, R., Nurhayati, S., & Hapsari, D. (2019). Nutritional and functional properties of breadfruit flour. *Food Science and Biotechnology*, 28(5), 1401–1409.
- Yani, A., Putra, D. S., & Lestari, P. (2021). Relationship between water activity and shelf-life of flour products. *Journal of Food Quality*, 2021, 8867342.
- Yuan, Y., Zhang, L., & Li, M. (2018). Leavening mechanisms in bakery systems. *Food Chemistry*, 239, 1093–1102.
- Yuliarti, N., Kurniawan, A., & Sari, D. (2021). Consumer acceptance of tuber-based food products. *Journal of Sensory Studies*, 36(2), e12630.
- Zhang, Y., Liu, X., & Wang, L. (2020). Maillard reaction-induced color changes in flour-based foods. *Food Research International*, 129, 108857.