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Innovative Foods with Red Bean Flour: A Sensory and Economic Analysis

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ABSTRACT

Red beans are a food ingredient with limited applications and short shelf life. Given their rich nutritional profile, including high protein, fiber, and essential micronutrients, red beans serve as a valuable alternative ingredient in addressing nutritional deficiencies and promoting food security through the development of accessible and versatile food products. The aims of this study were developing the application of red bean flour as an alternative ingredient in food products, identify substitution formulas of red bean flour in food products that are acceptable to validators and panelists, evaluate consumer acceptance of the developed food products, and determine the selling price of the innovative food products as an outcome of the development process. The research method used was Research and Development (Define, Design, Develop, and Disseminate). This study resulted in 2 innovation products: Redbean Rollcake Pizza (Rebelliza) and Redbean Garlic Star (Rebegas) with 50% substitution of red bean flour, respectively. Sensory test was conducted by a team of experts (validators) and 30 semi-trained panelists consisting of students. The sensory attributes evaluated in the acceptance test included flavor, color, texture, and taste. Following the testing phase, the products were disseminated to the general public. The final results indicated that both products were well-received by the public. This research highlights the potential of red bean flour to enhance food security and improve nutritional diversity by offering sustainable and affordable alternatives to traditional ingredients.

Keywords: Culinary product, red bean, sensory test, substitution flour

INTRODUCTION

Red bean (*Phaseolus vulgaris L.*) is a widely cultivated legume in Indonesia, well recognized by the public. According to data from the Ministry of Agriculture (Kementerian Pertanian, 2015) the production of red beans in Indonesia reached 100,316 tons in 2014. The primary nutritional components of red beans include macronutrients such as carbohydrates (38.30% - 68.85%) and protein (10.56% - 46%), both of which are essential for human health. Additionally, red beans are a rich source of fiber, fat, and minerals, including iron, zinc, calcium, magnesium, phosphorus, potassium, and sodium (Mananga et al., 2021). Given their nutritional profile, red beans have the potential to serve as a high-value food source, contributing to enhanced community nutrition and food innovation. Specifically, red beans can support food security and contribute to food diversification. Red beans can serve as an alternative food source with potential applications as a substitution ingredient to enhance nutritional value. One practical approach is processing red beans into flour, which can be utilized in various innovative food products. This study highlights the

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nutritional benefits and potential contribution of red bean flour in enhancing food security through diversification.

Previous research reported that the use of red bean flour as a substitute for wheat flour in making cupcakes can increase protein content and a glycemic index value of 58.1, classifying it as a medium-glycemic-index food, which makes it nutritionally suitable for individuals mindful of blood sugar levels (Rahman Asih et al., 2019). The substitution of red bean flour for sorghum flour had a significant effect ($p<0.05\%$) on the increase in ash content, protein, fat, carbohydrates, energy, soluble fiber, insoluble fiber, total fiber, and antioxidant capacity of sorghum analog rice (Fauziyah et al., 2017). The combination of red bean flour with sago starch enhances its gluten-free value, making it a viable alternative for food products catering to individuals with gluten intolerance or celiac disease (Agustia et al., 2016b).Additionally, flour processing technology offers an effective solution for producing semi-finished products with extended shelf life, improved blending potential with other flours, and options for nutrient fortification. These properties, along with the ability to mold into various shapes and enable faster cooking times, align well with modern consumer demands for convenience and practicality in food preparation.

Bean flour is a semi-finished food product that can be used in cookie production and as a substitute for wheat flour in pastry and bakery products. However, one of the main drawbacks of legume-based food ingredients is their high beany odor, which can negatively affect consumer acceptance of the final products. The lipoxygenase enzyme present in red beans is responsible for producing a strong odor. Additionally, the high protein content in red beans contributes to the distinctive aroma characteristic of this food ingredient (Rumida et al., 2023). Additionally, the limited availability of comprehensive information on the characteristics of red bean flour in Indonesia has hindered its broader optimization and application in food product development. Therefore, this recipe development was conducted to introduce innovation in products utilizing red bean flour and to assess the acceptability of the final product among consumers.

PURPOSE OF THE STUDY

The aim of this research are as follows: (1) develop the application of red bean flour as an alternative ingredient in food products; (2) identify substitution formulas of red bean flour in food products that are acceptable to validators and panelists; (3) evaluate consumer acceptance of the developed food products; and (4) determine the selling price of the innovative food products as an outcome of the development process.

METHOD

Method of this research is a research and development (R&D) approach aimed at producing new products through a systematic development process. The research activities are integrated within the product development stages, requiring a combination of multiple research methods, including surveys, experimental research, and evaluation. The study was conducted at the Production Laboratory of the Department of Culinary and Fashion Engineering Education, Faculty of Engineering, Yogyakarta State University. The research was conducted from January to April 2016. This R&D study follows the 4D model (Define, Design, Develop, and Disseminate) as outlined by Endang Mulyatiningsih (2011). The define stage involves identifying reference recipes for the three baseline products to be developed. The design stage focuses on creating new recipe formulations, namely Rebelliza and Rebegas, using red bean flour as a substitution ingredient. The develop stage includes the first and second validation tests. The final stage, disseminate, involves introducing the products to the public through exhibitions open to the general audience.

This study commenced with preliminary research focusing on the production of red bean flour. The process involved several stages, beginning with the sorting of red beans to remove foreign materials such as gravel and dry leaves. The beans were then thoroughly washed using water, followed by steam blanching for 10 minutes. Subsequently, the steam-blanched red beans were soaked in water for 12 hours. The soaked beans were dried in an oven at a temperature of 60°C-70°C for 7 to 8 hours. Once dried, the red beans were ground using a grinder and sieved through a 100-mesh screen to obtain fine red bean flour. A detailed flow diagram illustrating the process of red bean flour production is presented in Figure 1.

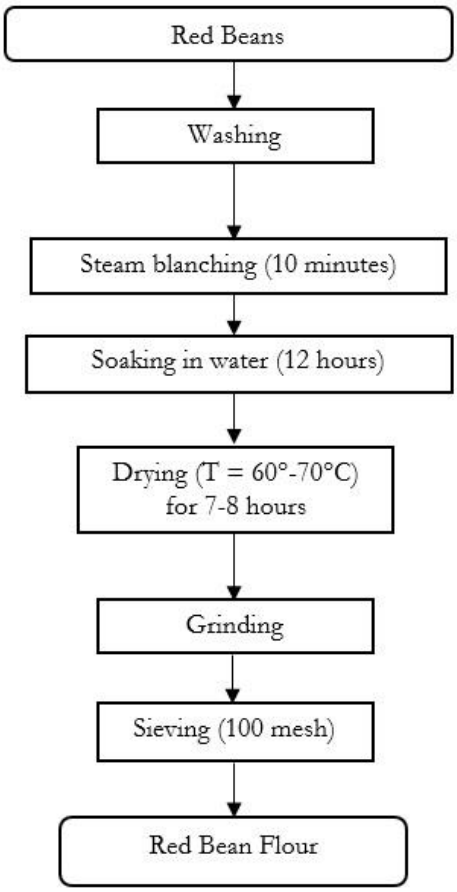

Figure 1. Flow Diagram of Red Bean Flour Production

Participants

This study developed two products: Redbean Rollcake Pizza and Redbean Garlic Star. The sample preparation involved several stages: identifying reference recipes as standards, formulating red bean flour substitution, conducting recipe trials, and producing the final products. The substitution percentages of red bean flour for each product were 0%, 25%, 50%, and 75%. The sensory attributes evaluated in the acceptance test included aroma, color, texture, and taste.

Data Collection and Analysis

Each product (sample) was validated by a team of experts (validators) to determine the percentage of red bean flour substitution that produced the best product. Furthermore, an acceptance test was conducted using the hedonic test method. The acceptance test was conducted by 30 semi-trained panelists consisting of culinary and fashion engineering education students of Faculty of Engineering, Yogyakarta State

University. The hedonic scale used in this study's hedonic test consisted of five levels: 1 = strongly dislike, 2 = dislike, 3 = moderately like, 4 = like, and 5 = strongly like.

FINDINGS

Redbean Rollcake Pizza (Rebelliza)

Product characteristics

Redbean Rollcake Pizza or Rebelliza is an innovative rollcake substitution of red bean flour with tuna fish pizza topping. The initial product design involved selecting a standard recipe according to the criteria, then this recipe will be used as a reference recipe. The reference recipe is substituted with Red Bean Flour with a different percentage of substitution. The red bean flour substitution recipe is outlined in Table 1.

Table 1. Rebelliza formula design

Ingredients	Red Bean Flour Substitution Formula			
	0%	25%	50%	75%
Red bean flour	0	12,5 g	50 g	37,5 g
Flour	50 g	37,5 g	50 g	12,5 g
Egg	4 eggs	4 eggs	4 eggs	4 eggs
Egg yolk	4 eggs	4 eggs	4 eggs	4 eggs
Margarine	100 g	100 g	100 g	100 g
Sugar	100 g	100 g	100 g	100 g
Ovalet	½ tsp	½ tsp	½ tsp	½ tsp
Maizena flour	5 g	5 g	5 g	5 g
Milk powder	5 g	5 g	5 g	5 g
Red food coloring	½ tsp	½ tsp	½ tsp	½ tsp

The best result of the four red bean flour substitution formulas was 50% substitution (see Table 2). This formula produces a soft texture, bright color and does not leave a distinctive aroma of red bean flour. The evaluation conducted by the validators rated the 50% red bean flour substitution formula as good, allowing the research to proceed to the next phase, the develop stage, to further refine the existing recipe.

Table 2. Characteristics of Substitution Formula Trial Results

Characteristics	Red Bean Flour Substitution Formula			
	0%	25%	50%	75%
Color	Light pink	Light pink	Slightly intense pink	Intense pink
Flavor	margarine sugar-like	margarine sugar-like	margarine sugar-like	margarine sugar-like
Texture	Extremely soft and mild	Soft and mild	Soft and mild	A little rough and heavy
Taste	Sweet and savory	Sweet and savory	Sweet and savory	Sweet and savory

Product Panelist Test

The panelist test was conducted at the Chemistry Laboratory of the Department of Culinary and Fashion Engineering, Faculty of Engineering, Yogyakarta State University. A total of 30 semi-trained panelists filled out the preference test forms that had been provided. The purpose of this panelist test is to determine the level of product acceptance from a small scale before finally being exhibited to the general public. The results of the panelist test can be seen in Table 3. This process helps in identifying any necessary improvements to the product based on panelist feedback, ensuring that the final product meets quality and

taste standards. Additionally, the feedback from the panelists provides valuable insights into consumer preferences, which can guide further product development and refinement.

Table 3. Panelist Acceptance of Rebelliza Products

Characteristics	Total Value	Average	Description
Flavor	98	3,26	Like
Color	103	3,43	Like
Texture	111	3,7	Like
Taste	103	3,43	Like

Data from the semi-trained panelist evaluation indicated that the flavor and taste of Rebelliza products were generally well-received and preferred. However, certain aspects require refinement, such as achieving an optimal balance between sweetness and savory flavors, which were noted as slightly imbalanced. Enhancing the intensity of the red bean aroma is also suggested to better emphasize its distinctive qualities. Furthermore, improvements in texture and mouthfeel are recommended to deliver a more cohesive and enjoyable sensory experience for consumers.

Exhibition

After passing the validation process and the semi-trained panelist test, to find out the public acceptance of Rebelliza products, an exhibition was held which was open to the general public. This exhibition was held at the Auditorium of YSU on Wednesday, April 19, 2017. In this exhibition, 75 products were provided for the general public, and each individual who sampled the product was required to complete a provided feedback form. The results of the hedonic test for the Rebelliza product are summarized in Table 4.

Table 4. General public acceptance of Rebelliza Products

Characteristics	Total Value	Average	Description
Flavor	215	3,25	Like
Color	227	3,43	Like
Texture	227	3,43	Like
Taste	223	3,37	Like

Based on the results of the recapitulation of the Rebelliza product liking test data at the exhibition, it is known that the aroma, color, texture and taste of Rebelliza products are accepted and liked by the public in Figure 2.

Figure 2. Rebelliza Product

Redbean Garlic Star (Rebegas)

Product characteristics

Redbean Garlic Star (Rebegas) is a cookie made with red bean flour substitution, characterized by a distinctive garlic stick flavor. Before the substitution, a standard recipe test was conducted, and the recipe that met the desired criteria was selected as the reference recipe. The reference recipe was then modified by substituting red bean flour at varying percentages. The red bean flour substitution recipe is outlined in Table 5.

Table 5. Rebegas product formula design

Ingredients	Red Bean Flour Substitution Formula			
	0%	25%	50%	75%
Red bean flour	0	43.75 g	87.5 g	131.25 g
Flour	175 g	131.25 g	87.5 g	43.75 g
Salt	5 g	5 g	5 g	5 g
Margarine	87.5 g	87.5 g	87.5 g	87.5 g
Egg	½ egg	½ egg	½ egg	½ egg
Garlic	1 clove	1 clove	1 clove	1 clove
Sugar	12.5 g	12.5 g	12.5 g	12.5 g

Table 6 shows that the use of red bean flour at higher concentrations significantly affects the texture of the cookies, making them harder. This is likely due to the high protein and fiber content in red bean flour, which can alter the gluten and reduce tenderness. However, a 50% substitution of red bean flour yielded the best results, producing cookies with a desirable crispy texture. The product exhibited a balanced garlic flavor, a savory and slightly salty taste, a crunchy texture, and a bright brown color. Despite these favorable characteristics, further improvements in color and texture are recommended to enhance the overall appeal and marketability of the product. This highlights the importance of optimizing the proportion of red bean flour to achieve a product that meets both sensory and structural quality standards.

Table 6. Characteristics of Substitution Formula Trial Results

Characteristic	Red Bean Flour Substitution Formula			
	0%	25%	50%	75%
Color	Bone yellow	Bone yellow	Brownish	Brownish
Flavor	Garlic-like	Garlic-like	Garlic-like	Garlic-like
Texture	Extremely crispy	crispy	Crispy	Firm
Taste	Savory	Savory	Savory	Redbean-like

Product Panelist Test

The panelist test was conducted at the Chemistry Laboratory of the Department of Culinary and Fashion Engineering, Faculty of Engineering, Yogyakarta State University. A total of 30 semi-trained panelists filled out the preference test forms that had been provided. The purpose of this panelist test is to determine the level of product acceptance from a small scale before finally being exhibited to the general public. The results of the panelist test can be seen in Table 7.

Table 7. Panelist Acceptance of Rebegas Products

Characteristics	Total value	Average	Description
Flavor	106	3.53	Like
Color	101	3.36	Like
Texture	109	3.63	Like
Taste	93	3.1	Like

Exhibition

After passing the validation process and the semi trained panelist test, to find out the public acceptance of Rebelliza products, an exhibition was held which was open to the general public. This exhibition was held at the Auditorium of YSU on Wednesday, April 19, 2017. In this exhibition, 75 products were provided for the general public, and each individual who sampled the product was required to complete a provided feedback form. The results of the hedonic test for the Rebegas product are summarized in Table 8.

Table 8. General public acceptance of Rebegas Products

Characteristics	Total value	Average	Description
Flavor	233	3,37	Like
Color	228	3,30	Like
Texture	242	3,50	Like
Taste	240	3,47	Like

The results of the acceptance test for the Rebegas product indicated that it was well received by the general public in Figure 3.

Figure 3. Rebegas Product

Selling price

According to Mulyadi (2005), the selling price is the amount charged to consumers, calculated based on the production costs plus non-production costs and the expected profit. Based on this definition, the formula for determining the selling price can be derived as Formula 1.

$$\text{Selling price} = \text{Production cost} + \text{Profit} + \text{Additional cost} \quad \text{.....1)}$$

Production costs include the costs of raw materials and all costs incurred during the processing of raw materials into finished products ready for market. Profit refers to the expected earnings, which are flexible and can be adjusted according to desired targets. Additional costs such as distribution and marketing (10% of production cost) should be considered for broader commercialization.

Rebelizza Selling Price

One recipe of Rebelizza yields 10 packages. The selling price is determined by adding the total production cost and profit, which is Rp46,605+(50%×Rp46,605)+(10%×Rp46,605). This calculation

results in Rp46,605+Rp23,302+Rp4,660=Rp74,567. Subsequently, the selling price per package is Rp74,567÷10=Rp7,456, which is then rounded to Rp7,500 per package. Therefore, the selling price of Rebelliza is Rp7,500 per package. The detailed production costs of Rebellizza can be examined in Table 9.

Table 9. List of Ingredients for Rebelliza Product

Ingredients	Amount	Unit Price (Rp)	Adjusted Price (Rp)
Raw materials costs			
Flour	25 g	Rp 10,500/kg	Rp 300
Redbean flour	25 g	Rp 45,000/kg	Rp 1,100
Margarine	100 g	Rp 4,000/2ons	Rp 2,000
Egg	8 eggs	Rp 16,500/kg	Rp 8,250
Sugar	100 g	Rp 13,000/kg	Rp 1,300
Ovalet	½ tsp	Rp 2,500/50g	Rp 250
Maizena flour	5 g	Rp 6,000/¼kg	Rp 100
Milk powder	5 g	Rp 3,500/27g	Rp 600
Food coloring	½ tsp	Rp 2,500/btl	Rp 50
Tuna	100 g	Rp 90,000/kg	Rp 9,000
Onion	70 g	Rp 17,000/kg	Rp 1,000
Garlic	2 clove	Rp 6,000/1ons	Rp 100
Jalapeno	2 pcs	Rp 40,000/kg	Rp 1,000
Mushroom	50 g	Rp 8000/1ons	Rp 4,000
Cheese	50 g	Rp 12,000/ ¼ kg	Rp 2,400
Salt	10 g	Rp 500/1ons	Rp 50
Pepper	10 g	Rp 1000/11gr	Rp 900
Margarine	15 g	Rp 4,000/2ons	Rp 300
Tomato sauce	100 g	Rp 8,900/½kg	Rp 1,800
Water	50 cc	Rp 3,000/600ml	Rp 250
Packaging	10 pcs	Rp 7,000/100pcs	Rp 700
Label	10 pcs	Rp 6,000/150pcs	Rp 400
Total raw materials cost			Rp 35,850
Additional costs			
Fuel, Electricity and water, Equipment depreciation	10% x Rp 35,850		Rp 3,585
Workforce	20% x Rp 35,850		Rp 7,170
Total costs			Rp 46,605

Rebegas Selling Price

One Rebegas recipe yields 25 pieces. The selling price is determined by adding the total production cost and profit. The calculation is Rp11,635+(50%×Rp11,635)+(10%×Rp11,635), which results in Rp11,635+Rp5,817+Rp1,163=Rp18,615. Subsequently, the selling price per piece is Rp18,615÷25=Rp744, which is then rounded to Rp800 per piece. Therefore, the selling price of Rebegas is Rp800 per piece. This pricing strategy not only covers the production costs but also ensures a reasonable profit margin, making it sustainable for small-scale producers. By setting the price at Rp800, the product remains affordable for consumers while still being profitable. Additionally, this approach allows for potential reinvestment in product development and marketing efforts to expand its market reach.

Table 10. List of Ingredients for Rebegas Product

Materials	Amount	Unit Price (Rp)	Adjusted Price (Rp)
Raw materials costs			
Flour	87.5 g	Rp 10,500/kg	Rp 900
Redbean flour	87.5 g	Rp 45,000/kg	Rp 3,900
Margarine	87.5 g	Rp 4,000/2ons	Rp 1,750
Egg	½ egg	Rp 16,500/kg	Rp 500
Garlic	1 clove	Rp 6,000/1ons	Rp 50
Sugar	12.5 g	Rp 13,000/kg	Rp 200
Salt	5 g	Rp 500/1ons	Rp 25
Packaging	25 pcs	Rp 2,500/100pcs	Rp 625
Label	25 pcs	Rp 6,000/150pcs	Rp 1,000
Total raw materials cost			Rp. 8950
Additional costs			
Fuel, Electricity and water, Equipment depreciation	10% x Rp 8,950		Rp 895
Workforce	20% x Rp 8,950		Rp 1,790
Total costs			Rp 11,635

DISCUSSIONS

Rebelliza, or Redbean Rollcake Pizza, represents a novel culinary innovation that incorporates red bean flour as a partial substitute, inspired by a roll cake combined with tuna pizza topping. Findings from this study revealed that Rebelliza achieved optimal outcomes with a 50% substitution of red bean flour, resulting in a soft texture, bright color, and an absence of the distinctive aroma often associated with red bean flour. The unpleasant odor produced by red beans is due to the lipoxygenase enzyme contained in red beans which is active in the processing process (Agustia et al., 2016a). Consistent with findings from (Rahman Asih et al., 2019) this substitution level also demonstrated the best results in terms of color and taste acceptance in similar baked products, such as cupcakes. The research of Husna & Syarif, (2022) explained that the substitution of red bean flour in making traditional food "Putu Ayu" had a significant effect on the quality of color and texture. Previous research developed an innovative method for producing mooncake pie crusts by incorporating 100% red bean flour as a substitute. This approach resulted in a product that was highly appreciated for its flavor, aroma, color, and texture (Usman et al., 2022). In addition, red bean flour can be substituted in making chocolate biscuits with 70% concentration based on the acceptance of panelists with sensory attributes, such as color, aroma, taste, and texture (Larasintya Jesriani & Riska, 2021). This aligns with the increasing emphasis on incorporating legumes such as red beans into functional food products due to their nutritional and sensory advantages (Agustia et al., 2016b).

Sensory evaluations conducted by semi-trained panelists confirmed the high acceptability of Rebelliza across key attributes, including color, aroma, texture, and taste. Red bean flour is a valuable ingredient known for enhancing the nutritional profile of food products by providing significant amounts of protein, carbohydrates, dietary fiber, and essential micronutrients, such as iron and magnesium (Mananga et al., 2021). In line with research (Kurnianingtyas et al., 2014), shows that the addition of red bean flour can increase protein and fiber levels in food products. Furthermore, replacing traditional wheat flour with red bean flour contributes to a lower glycemic index, making the product more suitable for individuals aiming to manage their blood sugar levels These findings highlight the potential of Rebelliza as a functional and

health-conscious food product that meets modern consumer demands for nutritious and flavorful alternatives.

Similarly, Rebegas, or Redbean Garlic Star, exemplifies another innovative product leveraging the benefits of red bean flour substitution, modeled as garlic-flavored stick cookies. Validator team assessments indicated that a 50% substitution of red bean flour produced the most favorable outcomes based on flavor, texture, and taste. This formulation delivered a balanced garlic flavor, a savory and slightly salty taste, a crunchy texture, and an appealing bright brown color. Sensory evaluations conducted by semi-trained panelists confirmed these results, demonstrating favorable acceptance across all attributes. Furthermore, exhibition feedback reinforced the positive reception, validating the product's market potential and consumer appeal.

The utilization of red bean flour not only improves the nutritional profile of Rebegas, providing protein, fiber, and essential minerals like iron and magnesium (Mananga et al., 2021) but also aligns with the increasing demand for healthier snack options among consumers (Rahayu et al., 2022; Sophia Perwita et al., 2021), incorporating garlic flavor enhances the sensory appeal of the product while offering potential health benefits, as garlic is known for its antimicrobial and antioxidant properties as it contains various compounds such as sulfur, allicin, and ajoene (Espinoza et al., 2020). To enhance nutritional diversity, red bean flour is commonly combined with other food ingredients, such as rice bran flour (Damayanti et al., 2020), mung bean flour for high protein snack bar (Dinda & Indrawati, 2023), mocaf flour for low energy high fiber snack bar (Pratama et al., 2020), cassava flour for emergency food bar (Hadiningsih et al., 2023), purple sweet potato as a alternative snack for diabetes mellitus (Zaddana et al., 2021), and black rice for low glycemix index (Ayunandha et al., 2021). Feedback from public exhibitions further emphasized the acceptability of Rebegas, suggesting its potential to satisfy consumer needs for both nutrition and flavor. These innovations underscore the adaptability of legumes in modern food applications, contributing to sustainable and health-oriented diets (FAO, 2019).

Moreover, the incorporation of legumes such as red beans into food products supports global objectives for sustainable food systems by providing an accessible and eco-friendly source of plant-based protein. This approach promotes dietary diversification and addresses food security challenges (FAO, 2019). Research has also demonstrated that substituting red bean flour in baked goods can enhance antioxidant capacity and deliver additional health benefits, making it an attractive option for health-conscious consumers (Rahayu et al., 2022). Such findings emphasize the dual potential of Rebelliza and Rebegas as innovative products that meet consumer preferences while addressing nutritional and sustainability goals.

CONCLUSION

This study successfully developed Rebelliza (Redbean Rollcake Pizza) and Rebegas (Redbean Garlic Star), incorporating red bean flour as a partial substitute (50% substitution for optimal results). Both products demonstrated high acceptability based on expert validation and sensory testing with semi-trained panelists and public exhibitions, showcasing their market potential. The established selling prices (Rp7,500 per package for Rebelliza and Rp800 per piece for Rebegas) indicate economic viability. The culinary innovations of Rebelliza and Rebegas have been positively received by both panelists and the public. These findings suggest the promising potential of red bean flour in creating functional, nutritious, and marketable food products that align with modern consumer demands and contribute to sustainable food systems. By integrating references and ensuring logical progression. Importantly, this research demonstrates the potential of red bean flour to enhance food security and nutritional diversity by providing a sustainable and affordable alternative ingredient, addressing the need for innovative and nutritious food products. The

findings contribute to a growing body of knowledge on utilizing underutilized legumes in food processing and offer practical implications for food entrepreneurs and the food industry in Indonesia.

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