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# Unlocking Flavor Potential of Cheese Balls Enriched with *Ipomoea batatas* var. Cilembu Assessed by Quantitative Descriptive Sensory Analysis

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## ABSTRACT

The increasing demand for healthier and functional food products has driven innovations in snack development using nutrient-rich local ingredients. This study aimed to develop Potablu Cheese Ball by substituting potato with Cilembu sweet potato and evaluating its sensory characteristics. Three formulations with different potato-to-sweet potato ratios (75:25, 50:50, and 25:75) were prepared. Sensory evaluation was conducted using hedonic and descriptive tests involving 30 semi-trained panelists assessing aroma, color, taste, and texture. The 25:75 formulation (Sample 926) received the highest scores in aroma (4.1) and flavor (4.4), showing strong consumer preference. Descriptive analysis confirmed the dominance of sweet aroma and flavor from Cilembu sweet potato. The findings indicate that incorporating Cilembu sweet potato enhances sensory quality and provides additional nutritional benefits. This product innovation highlights the potential of underutilized local commodities in developing functional, appealing snacks that align with consumer trends toward healthier diets.

### Contribution to Sustainable Development Goals (SDGs):

**SDG 2:** Zero Hunger

**SDG 3:** Good Health and Well-being

**SDG 12:** Responsible Consumption and Production

## 1. INTRODUCTION

### 1.1. Research Background

The increasing global demand for healthier and more functional food products has led to a growing interest in product development that utilizes nutrient-rich local ingredients. Changes in consumer lifestyles, especially those oriented toward health and wellness, have motivated researchers and industries to innovate food products that not only offer good taste and convenience but also provide additional nutritional benefits. These trends emphasize the importance of incorporating natural, functional ingredients into everyday food choices to address public health and nutritional concerns [1].

Among these, sweet potatoes (*Ipomoea batatas*) hold substantial agricultural and nutritional importance in Indonesia. As one of the world's largest producers, Indonesia ranks fourth globally in sweet potato production [2]. Cilembu sweet potato (*Ipomoea batatas* var. cilembu), a variety native to Indonesia known for its natural sweetness and high levels of beta-carotene, dietary fiber, and antioxidants [3]. Cilembu sweet potatoes are typically consumed roasted, producing a honey-like flavor due to increased reducing sugars, which also enhances their sensory appeal. These characteristics make Cilembu sweet potatoes an attractive option for inclusion in value-added food products aimed at health-conscious consumer (Marwani et al., 2023). Despite its potential, the use of Cilembu remains largely limited to traditional snacks such as boiled, fried, or roasted sweet potatoes and chips.

In this context, a new snack innovation named Potablu Cheese Ball was developed as a modified version of the



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conventional potato cheese ball by incorporating Cilembu sweet potato in varying ratios. The product was designed to improve sensory acceptability while enhancing its nutritional value through the inclusion of bioactive compounds from sweet potato. Potato itself provides starch and texture, while sweet potato introduces a natural sweetness, vibrant color, and added health benefits. By replacing part of the potato content with Cilembu sweet potato, not only can the nutritional profile of the product be enhanced, but also its sensory properties, such as flavor, aroma, and color, can be improved [5]. Previous studies have demonstrated that increasing the proportion of sweet potato in food products can enhance overall sensory acceptance due to its distinctive aroma and flavor profile [2,5–10]. Additionally, the baking or roasting of sweet potato increases the content of inulin and reducing sugars, contributing positively to texture and sweetness [3,4,11]. Thus, integrating Cilembu sweet potato into the formulation of cheese-based snacks represents a potential strategy for product differentiation and health-focused innovation.

To determine the most acceptable formulation of Potablu Cheese Ball, the study employed two complementary sensory evaluation techniques: hedonic testing and quantitative descriptive analysis (QDA). The hedonic test is an effective method used to measure consumer preference by assessing attributes such as aroma, taste, texture, and appearance using a structured 5-point hedonic scale ranging from "dislike very much" to "like very much" [12]. In contrast, the descriptive analysis involved semi-trained panellists evaluating the intensity of specific sensory attributes using defined scales, allowing for objective characterization of sensory differences among samples [13].

Data from both methods were analysed using non-parametric statistical tools to provide both consumer-driven insights and analytical sensory profiling, offering a robust framework for identifying the most acceptable formulation and guiding future product optimisation. By combining traditional food ingredients with rigorous sensory science, this research contributes to the development of innovative, health-oriented snack products grounded in local food traditions and scientific validation. This study also aligns with the Sustainable Development Goals (SDGs), particularly SDG 2: Zero Hunger, by promoting food innovation through the utilization of underexplored local resources that support improved nutrition and food system resilience [14].

## 1.2. Literature Review

### 1.2.1. New Product Development

New Product Development (NPD) refers to the comprehensive process of bringing a new product to market, encompassing idea generation, concept development, design, testing, and commercialization [15]. It is a strategic activity aimed at fulfilling market needs, responding to consumer trends, and maintaining a company's competitiveness. NPD is defined as a continuous, interdisciplinary process that transforms an idea into a market-ready product, ensuring alignment with user expectations, manufacturing feasibility, and organizational strategy [16].

NPD is crucial for sustaining competitiveness, meeting evolving consumer needs, and responding to dynamic market conditions. It enables organizations to introduce innovative

solutions, improve product quality, and reduce time-to-market while adapting to technological advancements and customer expectations [17]. NPD also supports strategic growth by optimizing internal resources, encouraging cross-functional collaboration, and integrating knowledge across disciplines. Moreover, it plays a crucial role in enhancing organizational learning, managing performance trade-offs, and aligning product outcomes with both operational goals and long-term business objectives [16].

Several factors influence the success of NPD. Internally, these include organizational structure, cross-functional collaboration, resource availability, leadership effectiveness, and innovation capabilities [18]. Externally, market dynamics, customer behavior, technological advancements, and competitive pressure play significant roles [15]. Effective management of both internal and external factors is essential to reduce failure rates, optimize development cycles, and ensure that the final product aligns with market expectations. Product development in the food sector involves a series of strategic steps aimed at meeting market demands and consumer expectations, particularly in terms of sensory characteristics and nutritional quality. Modification of existing products by substituting key ingredients is a common method employed to reduce development costs and increase competitiveness [13].

### 1.2.2. Potatoes

Potatoes (*Solanum tuberosum*) are herbaceous annual plants belonging to the Solanaceae family, which also includes tomatoes, eggplants, and peppers. Originating in the Andes of South America, they were first domesticated over 7,000 years ago and have since become one of the world's most important food crops [19]. Potatoes are classified as tuberous crops and are primarily valued for their underground storage organs that serve as rich sources of carbohydrates. In addition to their high starch content, they provide resistant starch, quality protein, and dietary fiber. Nutritionally, potatoes are also a good source of several essential micronutrients such as vitamin C, vitamin B6, potassium, magnesium, iron, zinc, and phosphorus [20]. Furthermore, they contain a variety of bioactive compounds including carotenoids, anthocyanins, chlorogenic acid, and glycoalkaloids, which contribute to their antioxidant, anti-inflammatory, and potential anticancer properties. These characteristics make potatoes a nutrient-dense food with both dietary and functional health benefits [21].

### 1.2.3. Cilembu Sweet Potatoes

Cilembu sweet potato (*Ipomoea batatas* L.), a member of the Convolvulaceae family and native to tropical regions of Central and South America, is now widely cultivated in Indonesia and serves as one of the country's primary carbohydrate sources after rice, maize, and cassava [11]. This tuber crop plays a significant role in national food security and agro-industry due to its high productivity, rich carbohydrate and starch content (approximately 75.28%), and affordability [9]. Its popularity in Indonesia is further supported by its diverse varieties, traditional familiarity, and soft, naturally sweet texture—especially when baked, where it exudes a honey-like syrup [3]. In West Java, Cilembu sweet potato leads in both harvested area and productivity, with outputs between 429,372 and 485,065 tons from 2011 to 2015 [22]. Nutritionally, it offers vitamins, phytochemicals, dietary fibers (pectin, cellulose, hemicellulose), minerals, and a very low fat

content of just 0.1 g, making it not only a culturally valued food but also a health-promoting one [6].

#### 1.2.4. Cheese Ball

Potato cheese balls are savory snack products developed through a combination of cheese-based innovation and potato processing. Originally created to optimize the use of excess cheese in food businesses, these snacks consist of a blend of various types of cheese, typically soft white cheese, mixed with selected spices and herbs such as black cumin, chives, sesame, parsley, and pepper to enhance flavor and aroma [23]. They are often served as part of cold buffets or appetizer menus and can be consumed as-is or processed further by incorporating eggs and flour, then either baked or deep-fried to obtain a golden, crispy outer layer. The incorporation of cheese makes this product a valuable source of essential nutrients, including protein, vitamins, and minerals, making it popular among consumers of all ages.

An adaptation of this concept is the potato-based version known as the potato ball, which originates from the creative modification of mashed potato mixed with wheat flour, cornstarch, and salt, then coated with breadcrumbs for frying. This variation has gained popularity due to its soft, creamy interior and crispy exterior, offering a rich, appealing taste profile and a round, visually attractive shape. As a result of increasing consumer interest in convenient, flavorful snacks, potato cheese balls have emerged as a promising food innovation that caters to modern dietary preferences while also providing a satisfying texture and distinct aroma [24].

#### 1.2.5. Sensory Analysis

In food product innovation, sensory evaluation plays a crucial role in assessing consumer preferences and guiding formulation adjustments. Sensory analysis is a scientific method used to evaluate the sensory characteristics of food and other consumer products through human senses such as sight, smell, taste, touch, and hearing [12]. The process involves clearly defining the testing objective, selecting and training panelists (either expert or consumer-level), preparing and randomizing samples, conducting evaluations using methods like difference testing, descriptive analysis, or hedonic preference tests, and applying statistical tools to interpret the results [25]. Several factors influence the accuracy and reliability of sensory analysis, including physiological conditions (e.g., age, fatigue, and health), psychological states (such as expectations, mood, and past experiences), and environmental settings (like temperature, lighting, and sample presentation) [26]. Effective control of these variables is essential to ensure that sensory evaluations yield valid and meaningful results, particularly in supporting product development, quality assurance, and consumer satisfaction [27].

#### 1.3. Research Objective

This study aims to develop an innovative functional snack product by incorporating Cilembu sweet potato as a partial substitute for potato in the formulation of Potablu Cheese Ball, and to evaluate its sensory acceptability (aroma, color, taste, and texture) using hedonic and descriptive analyses in order to identify the optimal formulation that meets consumer preferences and enhances nutritional value.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The primary ingredients used in the Potablu Cheese Ball formulation included boiled potatoes, roasted Cilembu sweet potatoes, mozzarella cheese, cornstarch, wheat flour, eggs, breadcrumbs, salt, and pepper. All ingredients were sourced locally from certified suppliers around Surabaya, Indonesia. The raw materials were selected based on maturity, freshness, and cleanliness.

### 2.2. Product Formulation

Three formulations were developed using varying ratios of potato to Cilembu sweet potato:

Sample 173: 75% potato : 25% sweet potato

Sample 497: 50% potato : 50% sweet potato

Sample 926: 25% potato : 75% sweet potato

Each sample contained a fixed amount of mozzarella cheese (5 g), cornstarch (15 g), wheat flour (5 g), egg (1), breadcrumbs (50 g), salt (2 g), and pepper (2 g).

### 2.3. Product Development

Potatoes and sweet potatoes were steamed and mashed. They were then mixed with the other ingredients to form a homogeneous dough. Each portion was shaped into a ball (diameter  $\pm 4$  cm), coated in breadcrumbs, and deep-fried at 170°C for 3–5 minutes until golden brown.

### 2.4. Sensory Evaluation

Sensory analysis was conducted using both hedonic testing and descriptive analysis. Thirty semi-trained panelists from PT Parewa Asian Catering participated. Hedonic tests were performed on aroma, color, flavor, and texture using a 5-point scale (1 = dislike very much, 5 = like very much). Descriptive analysis employed scaling from 1 to 5 for each attribute, indicating intensity levels. Data were statistically analyzed using Friedman-Conover test and interpreted using radar chart visualization.

## 3. RESULT AND DISCUSSION

Potablu Cheese Ball is produced using a base formulation that combines boiled potatoes and Cilembu sweet potatoes in varying ratios, along with mozzarella cheese, cornstarch, wheat flour, egg, salt, pepper, and a bread crumb coating. The ingredients are homogenized into a dough, shaped into 4 cm balls, and deep-fried at 170°C for 3–5 minutes as shown on Figure 1. Each level was assigned a random code based on a million random digits to minimize bias during sensory evaluation. Panelists received one sample per treatment, with identical shape and size, and evaluated them using hedonic and descriptive methods.



**Fig 1.** Potablu Cheese Ball appearance before frying

The hedonic method which is a subjective sensory evaluation technique, was chosen in this study to determine consumer preference among three Potablu Cheese Ball formulations with varying potato and Cilembu sweet potato ratios. Panelists rated color, aroma, taste, and texture using a 5-point hedonic scale, where 1 indicated "strongly dislike" and 5 "strongly like." This method was selected to identify the most preferred sample based on sensory acceptability. Data were analyzed using the Friedman-Conover test, a non-parametric method suitable for comparing more than two samples with subjective responses. A chi-square value exceeding 5.99 indicated significant differences, followed by pairwise comparisons to identify specific variations among the samples. The statistic can be seen at Table 1.

**Table 1.** Panelist preferences of Potablu Cheese Ball

Sample code	Parameters			
	Aroma	Color	Taste	Texture
173	3,6 <sup>a</sup>	3,7 <sup>a</sup>	3,6 <sup>a</sup>	3 <sup>a</sup>
497	3,4 <sup>ab</sup>	3,73 <sup>a</sup>	4 <sup>ab</sup>	3,5 <sup>ab</sup>
926	4,1 <sup>bc</sup>	3,8 <sup>b</sup>	4,4 <sup>bc</sup>	3,8 <sup>bc</sup>

Note: Different notations indicate a significant difference ( $P < 0.05$ ).

Sample 926 was rated highest across all descriptive parameters, particularly aroma and sweetness, confirming the dominant presence of the characteristic sweet flavor and aroma of Cilembu sweet potato. The increase in volatile compounds and reducing sugars due to roasting likely enhanced the sensory appeal (Kam & Kumalasari, 2022; Annisa, 2016).

### 3.1. Aroma

Aroma is one of the sensory attributes that can significantly influence consumer acceptance. It is the result of volatile compounds entering the nasal cavity [28]. In this study, the aroma parameter was assessed using the hedonic method to determine the impact of Cilembu sweet potato on consumer acceptance. The expected aroma in this product was the distinct scent of Cilembu sweet potato, which was intended to enhance the product's identity and support brand differentiation. The hedonic test results showed that sample 926 (25% potato: 75% Cilembu sweet potato) achieved the highest average aroma score of 4.1, indicating a

"like" rating from the panelists. This pattern indicates that higher proportions of Cilembu sweet potato enhance the aroma's acceptability.

The sweet and slightly caramelized aroma typical of roasted Cilembu sweet potatoes appears to contribute positively to consumer perception. Sample 926, with the highest Cilembu concentration, emitted a stronger, more appealing aroma, which could be why it received the highest liking score. Apriyanti, *et al.* (2025) sweet potatoes are known to contain distinctive volatile compounds that persist through processing. The variety and intensity of these volatiles influence perceived aroma, meaning that different sweet potato ratios can significantly affect the product's aromatic profile [9].

### 3.2. Color

Color is the first sensory attribute perceived by consumers through visual observation. According to Tarwendah, color is considered the most important sensory attribute because it strongly influences consumers' first impressions [28]. In this study, the color parameter was evaluated using the hedonic method to determine the effect of varying proportions of Cilembu sweet potato and potato on the appearance of Potablu Cheese Ball. The expected color for this product was a bright orange hue, aimed at creating a positive initial impression when consumers view and consume the Potablu Cheese Ball.

In the hedonic evaluation, the color attribute did not show a significant difference among the three samples ( $\chi^2 = 1.35 < 5.99$ ). All samples received similar average scores—sample 926 slightly led with a score of 3.8, followed by sample 497 (3.73) and 173 (3.7). All scores fell within the "like somewhat" category, indicating general acceptability but no clear preference. The similarity in color scores is likely because all samples were coated with the same bread crumbs and deep-fried under uniform conditions, giving them a comparable golden-orange external appearance regardless of the internal sweet potato ratio. This uniformity in crust color masked any inherent variation due to the sweet potato content.

Islami *et al.* noted that the addition of  $\beta$ -carotene-rich ingredients like Cilembu sweet potatoes can enhance yellow-orange hues in food products [5]. However, in this case, the visual impact was moderated by the external breading, which dominated the appearance.

### 3.3. Taste

Taste is a crucial factor in the development of new products, with the main expectation being that the product has a flavor acceptable to the majority of consumers. The taste parameter is essential to be evaluated through hedonic testing so that the product's flavor profile can be assessed, ultimately leading to a more marketable and consumer-friendly product [28]. The expected taste of Potablu Cheese Ball is the distinctive natural sweetness of Cilembu sweet potato.

Taste was one of the most differentiated attributes in the hedonic test. Sample 926 achieved the highest average score of 4.4 ("like"), significantly higher than sample 497 (4.0) and sample 173 (3.6). The Friedman-Conover analysis yielded  $\chi^2 = 13.07$ , confirming a significant difference among samples, with sample 926 being statistically superior to 173.

This outcome suggests that the higher the proportion of Cilembu sweet potato, the more favorable the taste is to consumers. The natural sweetness of the Cilembu variant

complements the savory flavor of cheese and starch, creating a complex and pleasing taste profile that enhances consumer acceptance.

Rahardjo and Sihombing stated that Cilembu sweet potatoes, especially when roasted, develop a distinct sweet and honey-like flavor, which can dominate the taste profile of mixed formulations [6]. This property likely contributed to the taste enhancement observed in sample 926.

### 3.4. Texture

Texture is a physical property of a product that can be perceived through the sense of touch or mouthfeel [28]. Texture plays a significant role in determining consumer preference, as it leaves a lasting impression during consumption. The hedonic test for the texture parameter aims to assess the product's suitability for consumption, ensuring it is both acceptable and enjoyable. The expected texture of the product is the characteristic crispiness typical of a Potato Cheese Ball.

The texture attribute in the hedonic test also revealed significant differences ( $\chi^2 = 9.05 > 5.99$ ). Sample 926 had the highest average score of 3.8, indicating "like somewhat", followed by sample 497 (3.5) and 173 (3.0). This shows a preference toward samples with higher Cilembu content, although the scores suggest moderate rather than strong preference.

The texture preference may be attributed to the soft and creamy consistency provided by the higher amount of sweet potato in sample 926, which melts slightly when fried and contrasts well with the crispy outer crust. Meanwhile, sample 173, with a higher potato content, was firmer and perhaps less palatable.

According to Melda *et al.* (2023), the heating of Cilembu sweet potatoes promotes the breakdown of starches and the development of inulin and reducing sugars, which can enhance moistness and softness in processed foods [10]. This supports the improved textural perception of samples with more Cilembu.

### 3.5. Descriptive Analysis

The descriptive test was conducted to complement the previous hedonic evaluation by identifying differences in sensory quality among the samples. Panellists assessed four attributes: aroma, taste, texture, and colour, using a 5-point quality scale, with higher scores indicating stronger intensity or more desirable characteristics. The results were averaged and visualised using a radar chart, as shown in Figure 2, where a wider spread toward the outer edges signifies better sensory quality.

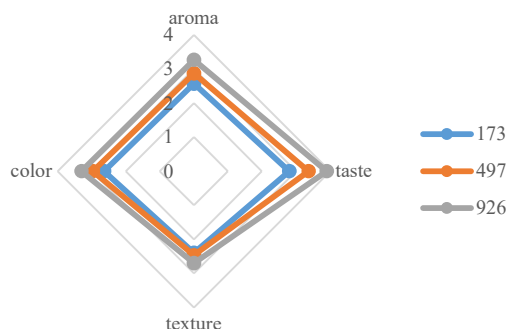


Fig 2. Radar chart of Potablu Cheese Descriptive Analysis

Among the samples, code 926 (with the highest proportion of Cilembu sweet potato) consistently showed the highest scores across all attributes. The results indicate that increasing the proportion of Cilembu sweet potato intensifies the sensory descriptors. The aromatic compounds, natural sugars, and  $\beta$ -carotene contribute to a richer sensory experience, aligning well with both hedonic preferences and technical description.

These observations are consistent with Tarwendah (2017), who emphasized that descriptive analysis provides insight into the actual sensory properties, allowing for product profiling and comparison among formulations [28]. In this study, both subjective (hedonic) and objective (descriptive) methods converged on sample 926 as the best performer in terms of sensory quality.

## 4. CONCLUSION

The development of Potablu Cheese Ball by incorporating Cilembu sweet potato significantly improved the sensory quality and nutritional value of the product. The 25:75 ratio of potato to sweet potato (Sample 926) was most preferred by panelists, especially in flavor and aroma. This study highlights the potential of local agricultural resources, such as Ubi Cilembu, in enhancing processed food innovation. Further research on shelf-life stability and nutrient retention is recommended to support commercialization.

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