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Article

Innovative Utilization of Banana Corm Flour (KuBoS): An Experimental Study on Sustainable Cookie Product Development

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Article Info

5st AVES
Annual Virtual Conference of
Education and Science 2025

Keywords:

*Agricultural waste utilization;
Banana corm flour;
Local resource-based food*

ABSTRACT

The increasing global emphasis on sustainable food innovation encourages the utilization of agricultural waste as an alternative raw material. This study introduces KuBoS (Kukis Bonggol Pisang), an innovative cookie product developed using banana corm flour (*Musa acuminata balbisiana*) as a substitute for low-protein wheat flour. The objectives of this study were to (1) formulate an optimal recipe using banana corm flour and (2) evaluate the sensory quality of the product in terms of taste, aroma, and texture. This research employed an experimental design combined with organoleptic testing conducted by 30 trained panelists. Data were collected through hedonic sensory evaluation using a three-point quality scale and analyzed descriptively using qualitative and quantitative methods. The final formulation consisted of 90 g banana corm flour, 30 g cornstarch, 30 g milk powder, 90 g arrowroot flour, 100 g margarine, 50 g powdered sugar, one egg yolk, 4 g vanilla powder, and 4 g salt. The results indicated that the KuBoS cookies achieved “good” ratings across all sensory attributes: a sweet-savory flavor, a distinct banana aroma, and a crisp texture. These findings suggest that banana corm flour can be used as a sustainable and functional food ingredient, promoting waste reduction, food diversification, and local economic empowerment. The study highlights KuBoS as an example of community-based food innovation contributing to environmental and economic sustainability

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INTRODUCTION

Ponorogo Regency possesses a wide range of natural resource potentials, particularly in agricultural commodities such as various types of fruits, one of which is the kepok banana (*Musa acuminata balbisiana*). This banana species originates from the Southeast Asian region, including Indonesia. Almost all parts of the banana plant its fruit, corm, leaves, stem, and blossom can be utilized in various ways. The fruit, leaves, stem, and blossom are commonly

used as food ingredients. For instance, bananas are processed into fried bananas, banana chips, or dried bananas (sale pisang); banana leaves are used for food wrapping or decoration; young banana stems are cooked into sayur lodeh ares, a traditional East Javanese dish; and banana blossoms are typically prepared as stir-fried banana blossoms. In contrast, the banana corm, which is the enlarged, tuber-like base of the banana plant, remains underutilized by the community. The corm has a brown outer skin and white inner flesh and is usually left to rot after harvest, occasionally used as livestock feed, or discarded entirely. One potential solution to this problem is to process banana corm waste into flour, which can extend its shelf life and increase its economic value. The conversion into flour is particularly important since fresh banana corms are highly perishable.

Experimental analyses have demonstrated that banana corm flour from the kepok variety yields superior nutritional quality compared to other banana types, such as the raja and Ambon varieties. According to Sembiring (2017), the nutritional composition of kepok banana corm flour consists of 79.16% carbohydrates, 2.15% fat, and 3.58% protein. Saragih (2013) further reported that the flour contains 29.62% crude fiber, 0.99% moisture, and 1.83% ash, with a light brown color and higher overall quality than other banana flours. These findings suggest that kepok banana corm flour can serve as an alternative to low-protein wheat flour due to its superior nutrient content. In agreement, Saragih (2013) also stated that kepok banana corm flour could function as a substitute for low-protein wheat flour in various food products, including cookies. Based on this rationale, the present study utilizes banana corm waste from the kepok banana variety as a substitute for wheat flour in the production of cookies. This research originates from the fundamental issue of the underutilization of agricultural by-products, particularly banana corms, which are often discarded despite their nutritional potential. While other parts of the banana plant such as the fruit, leaves, and stem are widely used for culinary or commercial purposes, the corm is frequently overlooked and considered to have little or no economic value (Saragih, 2013). In fact, nutritional analyses indicate that the kepok banana corm contains 79.16% carbohydrates, 2.15% fat, 3.58% protein, and 29.62% crude fiber, with a low moisture content (0.99%), making it a promising alternative ingredient to replace low-protein wheat flour (Sembiring, 2017; Saragih, 2013).

The utilization of agricultural by-products as alternative raw materials for food innovation has become a growing focus in sustainable food research. One of the underutilized local resources in Ponorogo Regency is the banana corm from the kepok banana variety (*Musa acuminata balbisiana*), which contains high carbohydrate (79.16%), moderate protein (3.58%), and fiber content (29.62%) (Sembiring, 2017; Saragih, 2013). In recent years, studies have explored the conversion of banana corm waste into flour as a substitution for wheat flour, aiming to reduce post-harvest waste and strengthen local food independence (Nuha & Fauziyah, 2024; Saputra et al., 2024). Experimental trials have shown that cookies made with banana corm flour substitution exhibit increased fiber content and distinctive sensory characteristics, including aroma and texture, which remain acceptable to consumers (Nuha & Fauziyah, 2024; Mumpuni, 2023).

From a nutritional standpoint, banana-based flours whether derived from fruit, pseudo-stem, or corm offer promising macronutrient profiles that can partially replace wheat flour in baked products (Yulia et al., 2022; Dela Cruz & Aggabao, 2025). Studies on composite flours from banana corm and tempeh have demonstrated improved protein levels and moisture stability, suggesting the potential for nutritionally enhanced cookies and pastries (Industria Journal, 2024). In line with the principles of sustainable food innovation, utilizing banana corm flour aligns with the zero-waste agricultural concept and circular economy models by transforming organic waste into high-value functional ingredients (Nurhaliza & Setyaningsih, 2021; Putri et al., 2020). Moreover, local-scale food enterprises can apply this

technology easily without high capital investment, supporting rural economic empowerment (Wulandari et al., 2020; Lestari & Puspitasari, 2022).

Organoleptic studies have reported that products containing banana corm flour substitution exhibit significant differences in color, taste, and aroma, yet remain within acceptable sensory limits (Saputra et al., 2024; Aprilianti et al., 2024). Variations in formulation ratios (25%–75%) influence the physicochemical and sensory properties of cookies, particularly fiber content and water absorption capacity (Mumpuni, 2023). Comparative analyses indicate that the kepok banana corm produces higher carbohydrate and crude fiber content than other banana varieties, making it suitable for low-protein wheat flour substitution (Nur Buwono et al., 2023; Fitriani et al., 2022). Integrating these findings, the innovation of KuBoS (*Kukis Bonggol Pisang*) represents a form of sustainable food development that contributes to three key pillars: environmental conservation, local economic growth, and food security. This effort demonstrates that the transformation of banana corm waste into flour-based products not only reduces organic waste but also enhances local community resilience through diversified and environmentally friendly food products (Putri et al., 2020; Nurhaliza & Setyaningsih, 2021).

This innovation integrates the concepts of sustainable food development and local-based innovation, making it feasible for application at the small and medium enterprise (SME) level without requiring advanced technology. Consequently, KuBoS exemplifies an environmentally friendly food innovation rooted in local wisdom that can enhance rural economic development. The study addresses three main perspectives: environmental, economic, and food security. From the environmental perspective, utilizing banana corms helps reduce organic waste and aligns with the principles of zero-waste agriculture (Nurhaliza & Setyaningsih, 2021). From the economic perspective, this research promotes diversification of local food enterprises and reduces dependence on imported wheat flour (Putri et al., 2020). From the perspective of food security, the use of locally sourced, nutrient-rich ingredients strengthens the principles of food security and food sovereignty, emphasizing community self-sufficiency based on regional potential. Academically, this research enriches the literature on local food innovation and provides a practical model for the development of high-value, sustainable food products derived from agricultural by-products, contributing to both scientific advancement and community based economic empowerment.

METHOD

The research method refers to the techniques and procedures employed in a study to ensure that its implementation and results can be scientifically justified. The present study utilized an experimental research design, which, according to Arikunto (2006), involves investigating an object through direct and controlled experimentation in the field. This research aimed to develop a cookie formulation made from kepok banana corm flour (*Musa acuminata balbisiana*), producing cookies that meet acceptable sensory and physical quality standards.

The experimental process was carried out on Friday, October 24, 2025, in Kauman Village, Kauman District, Ponorogo Regency, Indonesia. The research procedure began with the collection of banana corms by cutting down mature banana plants. The corms were cleaned by removing hard root residues using a machete. They were then thinly sliced with a knife to facilitate further processing. Each banana plant yielded approximately 3 kilograms of corm material. The sliced corms were then soaked overnight in a solution made from 5 liters of water mixed with 3 tablespoons of slaked lime (calcium hydroxide). This soaking process was intended to remove the sticky sap from the corm. The lime solution, which has strong

alkaline properties (pH 11–12.5), effectively neutralizes and eliminates the sap due to its high basicity.

After soaking overnight, the banana corm slices were thoroughly rinsed three times with clean water to remove any remaining lime and sap residues. The washed slices were then dried under direct sunlight using bamboo trays (tampah) for three consecutive days until completely dehydrated. Once dried, the material was ground using a blender to obtain fine banana corm flour suitable for cookie production. The tools used in this experiment included a whisk, manual oven (tangkring oven), mixing bowls, blender, and other baking utensils. The ingredients used in cookie formulation consisted of banana corm flour, arrowroot starch, cornstarch, powdered sugar, margarine, egg yolk, vanilla extract, and milk powder.

The experimental design employed three different formulations to determine the most acceptable sensory and physical characteristics of the cookies. The detailed composition of each formula is presented in Table 1, showing the proportion of ingredients used in each variation of KuBoS Cookies (Kue Bonggol Pisang).

Table 1. Formulation of KuBoS Cookies (Kue Bonggol Pisang).

No	Description	Formulation 1	Formulation 2	Formulation 3
1	Banana corm flour	90 gram	110 gram	50 gram
2	Cornstarch	30 gram	20 gram	50 gram
3	Milk powder	30 gram	20 gram	50 gram
4	Margarine	100 gram	100 gram	100 gram
5	Arrowroot starch	90 gram	90 gram	90 gram
6	Vanilla powder	4 gram	4 gram	4 gram
7	Egg yolk	1 item	1 item	1 item
8	Powdered sugar	50 gram	50 gram	50 gram
9	Salt	4 gram	4 gram	4 gram

The production process of KuBoS (Banana Corm Cookies) was carried out through several stages. First, margarine and powdered sugar were mixed in a bowl and stirred until well blended. Next, the egg yolk was added to the mixture and stirred again until evenly combined. Subsequently, the dry ingredients namely banana corm flour, arrowroot starch, milk powder, cornstarch, and a small amount of salt were sifted beforehand to obtain a fine texture, then gradually incorporated into the mixture and kneaded until a smooth and pliable dough was formed. The prepared dough was then shaped using a piping tool (spuit) according to the desired design. The shaped cookies were baked in a preheated oven at 170°C for approximately 25 minutes, until fully cooked and golden brown. Once baked, the cookies were removed from the oven and allowed to cool at room temperature before being served or packaged for further evaluation.

A sensory evaluation, also known as an organoleptic test, was conducted to assess the level of sensory acceptance of the KuBoS Cookies developed using banana corm flour as a sustainable alternative ingredient. Sensory evaluation has long been utilized as a fundamental method in determining food quality, as it relies on human perception through the senses of taste, aroma, and texture to evaluate a product's overall characteristics. According to Setyaningsih et al. (2010), human sensory perception plays a crucial role in determining consumer acceptance and the market success of food products, as consumer preferences directly reflect the product's sensory quality and commercial value. Products that receive positive sensory responses by meeting and satisfying consumer expectations are considered to possess high sensory quality and strong market potential.

In this study, sensory data were collected through structured questionnaires distributed to 50 semi-trained panelists, consisting of 30 female and 20 male respondents, aged between 18 and 45 years. The evaluation focused on three primary attributes: taste, texture, and aroma, which serve as key indicators of consumer acceptance of the KuBoS Cookies. Each panelist completed the questionnaire based on their personal perception of the samples, rating their level of preference or dislike using a five-point hedonic scale.

Table 2. Categories

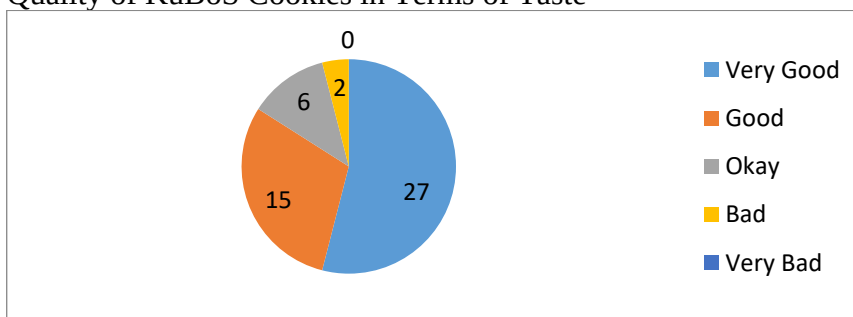
No	Skala	Explanation
1	5	Very Good
2	4	Good
3	3	Okay
4	2	Bad
5	1	Very bad

RESULT AND DISCUSSION

Data Collection Results Based on Organoleptic Testing

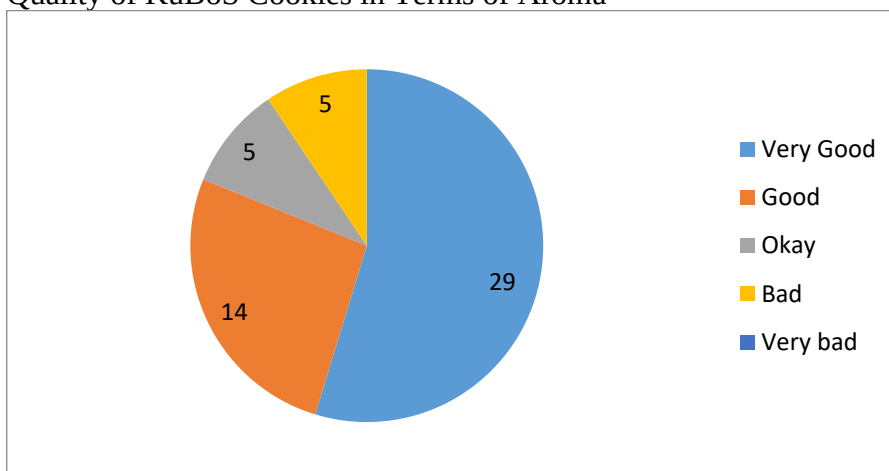
The results of this study focused on the KuBoS Cookies, which were evaluated for their quality based on taste, aroma, and texture attributes. In the experimental production of KuBoS Cookies, the best formulation was selected to test the overall quality and performance of the product. This formulation was chosen based on variations in the composition of banana corm flour used in the dough.

1) Quality of KuBoS Cookies in Terms of Taste



The results of the responses in terms of taste showed that out of 50 panelists, 27 individuals (54%) stated that they “strongly liked” the product, 15 individuals (30%) stated “liked,” 6 individuals (12%) stated “neutral,” while 2 individuals (4%) indicated “disliked,” and none of the panelists expressed “strongly disliked.” Thus, the total number of panelists who gave a positive response to the taste of the cookies (those who selected “like” and “strongly like”) reached 84%, which falls into the category of “highly preferred” according to sensory evaluation standards (Setyaningsih et al., 2010).

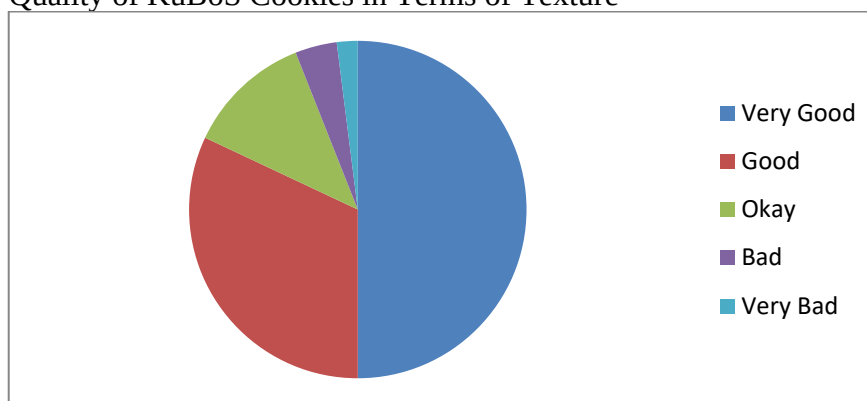
2) Quality of KuBoS Cookies in Terms of Aroma



Aroma is one of the main determining factors in food product acceptance, as it stimulates the consumer’s initial perception before tasting the product. Based on the results of the organoleptic test conducted on 50

panelists, it was found that 29 respondents (58%) stated that they “strongly liked” the aroma, 14 respondents (28%) stated “liked,” 5 respondents (10%) stated “neutral,” 2 respondents (4%) stated “disliked,” and none of the panelists stated “strongly disliked.” Thus, the total number of panelists who gave a positive response (categories “like” and “strongly like”) reached 86%, indicating that the product achieved a very high level of aroma acceptance.

3) Quality of KuBoS Cookies in Terms of Texture



Texture is one of the most influential physical attributes affecting the perceived enjoyment of bakery products, as it is directly related to the mouthfeel experienced during consumption. Based on the sensory evaluation conducted with 50 panelists, the results showed that 25 respondents (50%) stated “strongly like,” 16 respondents (32%) stated “like,” 6 respondents (12%) stated “neutral,” 2 respondents (4%) stated “dislike,” and 1 respondent (2%) stated “strongly dislike” toward the texture of cookies made with 50% banana corm flour substitution. Overall, the positive acceptance level for texture (categories “like” and “strongly like”) reached 82%, indicating that KuBoS cookies possess crispness and fragility that are well liked by most panelists.

Based on the sensory evaluation of the three main attributes—taste, aroma, and texture—it can be concluded that most panelists perceived the cookies with 50% banana corm flour substitution as highly pleasant in terms of taste. The sweetness was considered balanced, not overly strong, and harmonized with the soft, distinctive banana aroma. Panelists also noted that the flavor of these cookies had a unique natural character distinct from conventional wheat cookies, while still meeting consumer expectations for sweet bakery products. This finding indicates that using banana corm flour in moderate proportions helps maintain flavor balance without producing the bitterness or astringency commonly associated with high-starch ingredients. These results reinforce the statement of Sari et al. (2022) that the use of local ingredients such as banana corms can enhance the unique flavor characteristics of food products, especially when processed at the appropriate substitution ratio.

Panelists also commented that the characteristic banana aroma of the cookies provided a natural and appetizing impression without being overpowering. Volatile compounds such as amyl acetate and isoamyl alcohol present in banana ingredients are known to contribute to the sweet, fruity aroma typical of tropical fruits (Kusuma & Nuraini, 2021). The aroma

intensity of the 50% formulation was considered optimal—strong enough to increase appeal but not producing the earthy odor observed in the full substitution (100%) formulation. According to brief post-test interviews, the panelists described the cookies as crispy but not hard, with an ideal level of brittleness and easy to chew. The fiber content in the banana corm flour helped form a light porous structure, while the combination with wheat-based starch maintained dough stability. This aligns with the findings of Pradana and Fitriani (2023), who stated that partial substitution of high-fiber flour can improve cookie texture without compromising crispness.

Shelf-Life Test

The shelf-life test was conducted over 30 days of storage at room temperature (25–28°C) to evaluate changes in moisture content, texture, and aroma stability. During the first to third weeks, the cookies retained their characteristic banana aroma, consistent flavor, and crispy texture, with an average liking score of 4.20 (84%). However, in the fourth week, a slight decrease in preference score to 3.85 (77%) was observed, mainly due to a reduction in crispness. Moisture analysis showed an increase from 3.2% to 4.7%, but this value remained below the maximum threshold for dry cookies as specified in the Indonesian National Standard, which is less than 5%. These results indicate that KuBoS cookies remain safe for consumption and maintain good sensory stability for up to 30 days of storage.

The slight decline in texture quality was attributed to moisture absorption from the surrounding air, owing to the hygroscopic nature of the fiber in banana corm flour. According to Septiani and Lestari (2020), environmental humidity is the primary factor that accelerates texture deterioration during cookie storage, particularly in high-fiber products. Therefore, to extend shelf life, it is recommended to use multi-layer airtight packaging to preserve sensory stability and prevent moisture uptake.

SWOT Analysis of KuBoS Cookies

Aspect	Description
Strengths (S)	KuBoS Cookies are developed using locally abundant and underutilized banana corms, transforming agricultural waste into a valuable food product. The use of banana corm flour provides high fiber and mineral content, which enhances the nutritional profile of the cookies and promotes them as a healthy and eco-friendly snack. This innovation also supports the use of local raw materials, reducing dependence on imported wheat flour while aligning with the growing trend toward sustainable and responsible food production.
Weaknesses (W)	Despite its nutritional benefits, KuBoS Cookies have several weaknesses that require improvement. The cookies tend to have a more fragile texture compared to those made entirely from wheat flour, which may affect their handling and packaging. In addition, the dominant banana aroma becomes more noticeable when the substitution ratio increases, potentially limiting consumer acceptance. The production process also demands additional steps, such as drying and grinding banana corms, which contribute to higher operational costs and longer preparation time.
Opportunities (O)	The increasing public awareness of healthy and environmentally friendly food creates a promising opportunity for KuBoS Cookies to enter the functional food market. Consumers are becoming more interested in local products that offer health benefits and sustainability values, allowing KuBoS Cookies to position themselves as an innovative local brand.

	Furthermore, the growing support for small and medium enterprises (SMEs) in the food sector and the trend toward reducing food waste provide additional market potential for product expansion and promotion.
Threats (T)	KuBoS Cookies face several external threats that could affect their competitiveness. The market for healthy cookies is expanding rapidly, with many products made from familiar ingredients such as oats, cassava, and taro that already have strong consumer recognition. Moreover, public perception of banana corms as agricultural waste remains a challenge that may hinder acceptance. Without effective education and green marketing strategies, consumers may be hesitant to try the product, making it essential to build a positive brand image and emphasize its unique value proposition.

Based on laboratory test results and sensory evaluation findings, a SWOT analysis was conducted to determine the strategic position for the development of the KuBoS Cookies product. The product utilizes locally abundant and underused raw materials, namely banana corms, which are often discarded after harvest. The high fiber and mineral content of banana corm flour gives the cookies added nutritional value and positions them as a healthy and eco-friendly food product. According to Lestari and Rahmadani (2021), the substitution of non-wheat local ingredients can strengthen national food security and support zero-waste principles. The main weaknesses of KuBoS Cookies lie in their slightly more fragile texture compared to pure wheat cookies and the dominant banana aroma in higher substitution ratios. Additionally, the drying and grinding process of banana corms requires extra processing costs, which may increase production expenses.

The growing public awareness of healthy, sustainable, and locally sourced food provides significant opportunities for KuBoS Cookies to enter the eco-friendly food market segment. The product can be promoted as a local functional food innovation that supports the Sustainable Development Goals (SDGs) Goal 12: Responsible Consumption and Production (Hidayat et al., 2022). Potential threats include the increasing number of healthy cookie products made from oats, cassava, and taro, which are already more familiar to consumers. Moreover, the public perception of banana corms as “agricultural waste” still needs to be improved through public education and effective green branding strategies.

Considering all four aspects, the development strategy for KuBoS Cookies should focus on enhancing sensory quality standards, innovative packaging design, and consumer education on product sustainability values to increase competitiveness in the modern functional food market.

Attachment

1. Process of processing banana corm into flour





2. Process of making banana corm flour cookies



CONCLUSION

This study showed that KuBoS (Banana Corm Cookies) with a 50% substitution of kepok banana corm flour produced the best quality in terms of taste, aroma, and texture. A total of 84% of panelists liked the taste, 86% liked the aroma, and 82% liked the texture of the cookies. The 30-day shelf-life test indicated that the product remained stable, with moisture content increasing from 3.2% to 4.7%, still within the acceptable range according. Based on the SWOT analysis, KuBoS has strengths in utilizing nutrient-rich local ingredients, being environmentally friendly, and supporting the zero-waste concept. Its weaknesses include a slightly fragile texture and a dominant banana aroma; however, it holds significant development potential due to the growing public interest in healthy and sustainable food products. Overall, KuBoS Cookies are considered worthy of development as an innovative, nutritious, and sustainable local product with strong potential to enhance community-based economic growth.

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