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MORALITY BEFORE KNOWLEDGE

Gemoi Bite: Cookie formulation based on dandang gendis leaf extract and mocaf flour with the addition of soybean flour as a nutraceutical to stabilize blood glucose

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ABSTRACT
Background: The rise in diabetes cases, coupled with the increasing prevalence of gluten intolerance, has prompted the development of gluten-free nutraceutical products with the potential to stabilize blood glucose levels. The combination of *Clinacanthus nutans*, soybean flour, and MOCAF supports glycemic control through the synergistic action of bioactive compounds and soluble fiber that stabilize blood glucose levels. **Methods:** The research design used a Completely Randomized Design (CRD) with two formulation variations. The study was conducted in two stages, a preliminary phase for formulation optimization and a main experimental phase involving 30 trained panelists recruited through purposive sampling. Dandang Gendis leaves were processed via microwave-drying at 40°C to preserve bioactive compounds, while finalized cookies were subjected to standardized proximate analysis at Universitas Brawijaya and sensory evaluation using a four-point hedonic scale. **Findings:** The results showed that variations in the proportion of dandang gendis leaf extract and soybean flour significantly affected the ash, fat, carbohydrate, calorie content, and sensory attributes (taste, aroma, color, and texture). The flour concentration also affected most of the physicochemical and organoleptic parameters. The best formulation was obtained in formulation 2 with a combination of 15% dandang gendis leaf extract and 25% soybean flour. The physicochemical characteristics of the cookies included water content of 10.81%, protein 6.7%, fat 0.35%, carbohydrate 78.5%, ash 1.5%, energy 256.5 kcal, glycemic index 37, and active compound content of 0.4% (flavonoid 0.2%, isoflavone 0.1%, and saponin 0.1%). **Conclusion:** The best formulation for Gemoi Bite functional cookies is a combination of 80 g of dandang gendis leaves and 40 g of soy flour, which boasts excellent sensory qualities and blood sugar control benefits. **Novelty/Originality of this article:** The uniqueness of this research lies in the synergistic formulation of *Clinacanthus nutans* extract, soybean flour, and MOCAF to create a special nutraceutical cake for diabetes management.

KEYWORDS: dandang gendis leaf extract; soybean flour; mocaf flour; blood glucose stabilizer; nutraceuticals.

1. Introduction

Diabetes Mellitus Type II (DMT2) has increasingly been recognized as one of the most complex and challenging metabolic disorders affecting global populations in the modern era. As a chronic non-communicable disease, DMT2 is characterized by sustained hyperglycemia resulting from insulin resistance in peripheral tissues combined with progressive impairment of pancreatic beta-cell function, ultimately leading to inadequate insulin secretion (Widiasari et al., 2021). The multifactorial nature of DMT2 distinguishes it

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from other metabolic conditions, as it arises not from a single etiological factor but from an intricate interplay between genetic predisposition, behavioral patterns, environmental influences, and socioeconomic determinants.

From a global perspective, the prevalence of diabetes mellitus has increased at an unprecedented rate over recent decades, reflecting profound changes in dietary habits, physical activity patterns, and population aging. According to the International Diabetes Federation, an estimated 537 million adults worldwide were living with diabetes in 2021, and this number is projected to rise to 643 million by 2030 (International Diabetes Federation (IDF), 2021). These figures indicate not only a growing health burden but also a looming crisis for healthcare systems worldwide, particularly in low- and middle-income countries where resources for chronic disease management remain limited. The escalating prevalence of DMT2 underscores the urgent need for effective prevention strategies that address modifiable risk factors at both individual and population levels.

Indonesia exemplifies the rapid epidemiological transition associated with modernization and urbanization. In recent years, Indonesia has emerged as one of the countries with the highest number of diabetes cases globally. In 2024, the estimated number of individuals living with diabetes mellitus in Indonesia reached 20.4 million, placing the country among the top five worldwide in terms of diabetes burden. Projections suggest that this figure could rise dramatically to 28.6 million by 2050 if comprehensive and sustainable interventions are not implemented (International Diabetes Federation (IDF), 2021). At the subnational level, East Java has been identified as one of the provinces with the highest prevalence of diabetes mellitus, reporting 130,683 cases (BKPK, 2023). These data reflect not only the magnitude of the problem but also the uneven distribution of diabetes burden across regions, highlighting the importance of context-specific strategies.

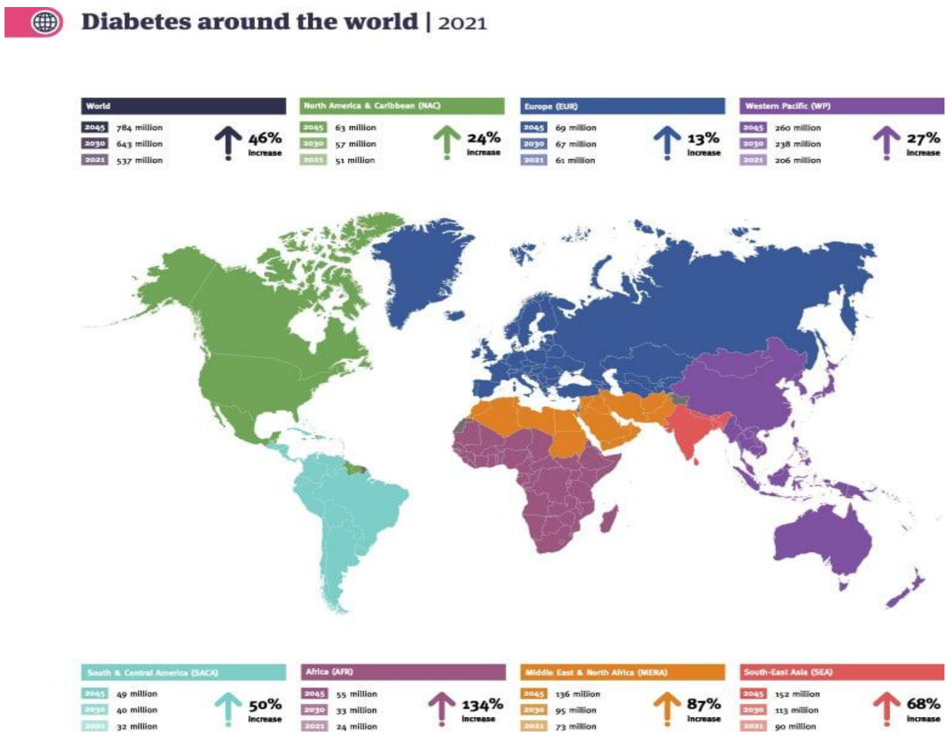

Fig. 1. Diabetes prevalention in 2021
(IDF Diabetes Atlas10 Edition, 2021)

The growing prevalence of DMT2 in Indonesia is closely linked to changes in lifestyle behaviors, particularly dietary patterns characterized by increased consumption of refined carbohydrates, sugary beverages, and processed foods, alongside reduced physical activity. Prolonged sedentary behavior, independent of insufficient physical activity, constitutes a significant metabolic risk factor. In individuals with type 2 diabetes mellitus, extended sitting is associated with impaired insulin sensitivity and poorer glycemic control.

Therefore, reducing sedentary time is an important adjunctive strategy in diabetes management (Damayanti, 2025). These lifestyle shifts have contributed to rising rates of overweight and obesity, which are major risk factors for insulin resistance. Insulin resistance, a hallmark of DMT2, occurs when peripheral tissues such as skeletal muscle and adipose tissue fail to respond adequately to insulin, resulting in reduced glucose uptake and elevated blood glucose levels. Over time, chronic insulin resistance places increased demands on pancreatic beta cells, leading to beta-cell dysfunction and eventual failure (Widiasari et al., 2021).

The clinical consequences of uncontrolled DMT2 are extensive and severe. Persistent hyperglycemia initiates a cascade of metabolic and vascular abnormalities that damage multiple organ systems. Individuals with poorly managed DMT2 are at significantly increased risk of developing macrovascular complications, including coronary artery disease, stroke, and peripheral vascular disease, as well as microvascular complications such as diabetic nephropathy, retinopathy, and neuropathy (Salsabila & Sjaaf, 2022). These complications contribute substantially to morbidity, disability, and premature mortality, while also imposing significant economic burdens due to long-term medical care and loss of productivity.

Given the chronic and progressive nature of DMT2, effective management requires long-term strategies that extend beyond pharmacological treatment alone. While antidiabetic medications play a crucial role in glycemic control, non-pharmacological interventions particularly lifestyle modification are widely regarded as the foundation of DMT2 management (Efliani et al., 2024). Dietary management and regular physical activity are essential components of diabetes care, as they directly influence insulin sensitivity, body weight, and metabolic regulation. Nutritional therapy for diabetes emphasizes the importance of balanced macronutrient intake, controlled carbohydrate consumption, selection of low glycemic index foods, and increased dietary fiber intake (Widiasari et al., 2021).

Despite clear clinical guidelines and extensive educational efforts, adherence to recommended dietary practices among individuals with DMT2 remains suboptimal. Many patients face barriers such as limited access to healthy food options, lack of nutritional literacy, socio-economic constraints, and cultural preferences for traditional foods high in carbohydrates. Snack consumption presents a particularly significant challenge, as snacks are often perceived as discretionary foods and are frequently high in refined carbohydrates and added sugars. For individuals with DMT2, inappropriate snack choices can result in rapid postprandial glucose spikes, undermining glycemic control and increasing the risk of long-term complications.

In response to these challenges, functional foods have emerged as a promising approach to support dietary management of DMT2. Functional foods are defined as foods that provide health benefits beyond basic nutritional value due to the presence of biologically active components that influence physiological functions. In the context of diabetes management, functional foods are designed to modulate glucose metabolism, enhance insulin sensitivity, reduce oxidative stress, and support overall metabolic health. Importantly, functional foods derived from locally available ingredients offer advantages in terms of affordability, cultural acceptability, and sustainability, making them particularly relevant in resource-limited settings.

Indonesia's rich biodiversity provides a valuable foundation for the development of functional foods based on traditional medicinal plants and local agricultural products. One such medicinal plant is *Clinacanthus nutans*, commonly known as dandang gendis. This plant has been widely used in traditional medicine for the treatment of various ailments, including inflammatory conditions, skin disorders, viral infections, and metabolic diseases (Klau & Hesturini, 2021). In recent years, scientific studies have increasingly validated the traditional uses of *Clinacanthus nutans*, particularly its potential antidiabetic properties.

Phytochemical investigations have revealed that dandang gendis leaves contain a diverse array of bioactive compounds, including flavonoids, tannins, and saponins, which contribute to its antioxidant and antidiabetic effects. Flavonoids are known to play a central role in glucose regulation through multiple mechanisms, such as enhancing insulin secretion from pancreatic beta cells, improving insulin sensitivity in peripheral tissues, increasing glucose uptake via upregulation of glucose transporter type 4 (GLUT4), and reducing oxidative stress associated with chronic hyperglycemia (Dewinta et al., 2020). These mechanisms collectively support improved glycemic control and protection of beta-cell function.

Saponins present in *Clinacanthus nutans* further enhance its antidiabetic potential by modulating key pathways involved in glucose metabolism. These compounds inhibit the activity of carbohydrate-digesting enzymes such as α-glucosidase, thereby reducing the rate of glucose absorption in the intestine. Additionally, saponins suppress hepatic gluconeogenesis, stimulate glycogen synthesis, and enhance insulin signaling pathways, all of which contribute to improved glucose homeostasis (Dewinta et al., 2020). Tannins also play a role in glucose regulation by activating insulin-mediated signaling pathways involving Mitogen-Activated Protein Kinase and Phosphoinositide 3-Kinase, facilitating GLUT4 translocation and promoting glucose uptake in muscle and adipose tissues (Dewinta et al., 2020).

From a community-based development perspective, dandang gendis cultivation is positioned not only as an agronomic activity but also as a strategic instrument for empowering rural communities. The plant's relatively easy cultivation characteristics, adaptability to various environmental conditions, and promising economic value enable its development through farmer groups. Furthermore, diversification of processed products based on dandang gendis can increase the commodity's added value, expand the value chain at the local level, and strengthen community economic resilience.

In parallel with medicinal plants, legumes such as soybean (*Glycine max*) have long been recognized for their nutritional and functional benefits in the management of metabolic diseases. Soybean is a rich source of high-quality plant-based protein, dietary fiber, and isoflavones, and it has a relatively low glycemic index. Isoflavones such as genistein and daidzein exhibit antioxidant and anti-inflammatory properties and have been shown to enhance insulin sensitivity by improving insulin receptor function and reducing oxidative stress. Soybean isoflavones act as phytoestrogens that help regulate glucose and lipid metabolism while providing anti-inflammatory and antioxidant effects beneficial for type 2 diabetes management. Additionally, soybean dietary fiber enhances insulin sensitivity and glycemic control through modulation of gut microbiota and gastrointestinal hormone activity (Mardhotillah, 2025). Empirical evidence suggests that regular consumption of soybean-based products can lead to significant reductions in fasting blood glucose levels and improvements in glycemic control among individuals with DMT2 (Hosea et al., 2022).

Soybean flour, as a processed derivative of soybean, offers additional advantages for food formulation. It retains the nutritional benefits of whole soybeans while providing flexibility for incorporation into a wide range of food products. Experimental studies using diabetic animal models have demonstrated that supplementation with soybean flour significantly reduces fasting blood glucose levels and enhances insulin sensitivity (Hosea et al., 2022). Furthermore, incorporation of soybean flour into food products such as cookies, flakes, and noodles results in products with low glycemic index, high protein content, and increased dietary fiber, making them suitable as functional foods for individuals with diabetes (Yanti, 2021).

Modified Cassava Flour (MOCAF) represents another locally available ingredient with considerable potential for diabetes-friendly food development. MOCAF is produced from cassava (*Manihot esculenta* Crantz) through controlled fermentation processes that improve its functional and nutritional properties (Udoro et al., 2021). Fermentation method significantly influences the efficiency of MOCAF production. Natural fermentation requires approximately three days, whereas enzymatic or microbial starter-assisted fermentation shortens the process to 12-36 hours. Thus, the type of fermentation agent plays a crucial role in determining production time and overall effectiveness (Hadistio et al., 2019). Compared to conventional wheat flour, MOCAF has a lower glycemic index, is gluten-free, and contains resistant starch that slows carbohydrate digestion and glucose absorption (Lestari et al., 2023). Resistant starch type 3 (RS3) present in MOCAF functions as a prebiotic, supporting gut microbiota health and contributing to improved insulin sensitivity.

Numerous studies have demonstrated that consumption of MOCAF-based products effectively supports glycemic control and reduces blood glucose levels (Hidayatullah et al., 2017). Food products formulated with MOCAF, such as noodles, brownies, and cookies, exhibit favorable sensory properties while maintaining low glycemic indices, making them acceptable alternatives to wheat-based products for individuals with DMT2 (Udoro et al., 2021). In addition to its health benefits, the use of MOCAF supports national food diversification initiatives and reduces dependence on imported wheat, thereby contributing to food security and economic sustainability.

Cookies offer a particularly effective medium for delivering functional ingredients aimed at diabetes management. As a widely consumed snack with high consumer acceptance and long shelf life, cookies can be reformulated to enhance their nutritional and functional properties. Traditionally, cookies are made using wheat flour, sugar, and fat, resulting in products with high glycemic load (BSN, 2022). However, previous research has shown that cookies are highly adaptable and can be modified using alternative flours and functional ingredients without compromising sensory quality. The incorporation of soybean flour and MOCAF into cookie formulations enhances protein and fiber content while reducing glycemic index.

Despite increasing interest in functional foods, existing research has largely focused on individual functional ingredients rather than synergistic formulations that combine multiple bioactive components. There remains a notable gap in the literature regarding the development and evaluation of snack products that integrate medicinal plant extracts, legume-based protein sources, and fermented tuber flours into a single functional food product. This gap underscores the need for research that explores the combined effects of these ingredients on product quality, acceptability, and potential health benefits.

The development of Gemoi Bite, a functional cookie formulated from dandang gendis leaf extract, soybean flour, and MOCAF, addresses this gap. The novelty of this study lies in the synergistic integration of bioactive plant compounds, high quality plant protein, and low-glycemic index carbohydrates into a single snack product specifically designed for individuals with DMT2. Based on the theoretical framework and empirical evidence discussed, it is hypothesized that the incorporation of these ingredients will result in a functional cookie with favorable organoleptic, hedonic, and proximate characteristics while supporting glycemic control. Furthermore, the incorporation of locally sourced vegetable protein can create meaningful economic linkages within rural communities (Farhan, 2025). The purpose of this manuscript is to comprehensively describe the production process of Gemoi Bite and to evaluate its organoleptic, hedonic, and proximate properties. This study aims to contribute to the growing body of knowledge on functional food development using local Indonesian resources and to provide a practical dietary option that supports the management of DMT2 while promoting sustainable public health solutions.

2. Methods

This research was designed as a quantitative study employing an experimental approach to systematically answer the research problem concerning the development and evaluation of a functional food product known as Gemoi Bite. The experimental method was selected because the object of the research namely the formulated cookie product possesses characteristics that can be directly observed, measured, and quantified through controlled procedures. Ontologically, this research is grounded in the assumption that sensory quality, acceptability, and nutritional composition of food products exist as empirical realities that can be objectively assessed. Epistemologically, knowledge in this study is generated through structured experimentation, standardized measurement, and systematic data analysis, allowing conclusions to be drawn based on observable evidence rather than subjective interpretation alone.

The research process was structured into two consecutive and interrelated stages to ensure methodological rigor and logical coherence. The first stage was a preliminary experimental stage, which aimed to identify an appropriate reference formulation for Gemoi Bite. This stage was necessary to establish a stable and feasible formulation prior to formal evaluation, as direct testing without prior optimization could result in unreliable or inconsistent outcomes. The preliminary stage therefore functioned as a foundational phase in which ingredient composition, processing sequence, and basic product characteristics were explored and refined. The outcomes of this stage informed the design of the second stage, ensuring continuity between formulation development and formal testing.

The second stage constituted the main experimental research phase, in which the finalized formulations were subjected to systematic evaluation through organoleptic testing, hedonic testing, and proximate analysis. These evaluations were selected to provide comprehensive data covering sensory quality, consumer acceptance, and nutritional composition. The integration of these assessments allowed the research to address both technical and practical aspects of product development, ensuring that the resulting product was not only nutritionally appropriate but also acceptable from a sensory perspective.

The research was conducted over a defined period from late July to mid-September 2025. This timeframe was deliberately chosen to ensure the availability and consistency of raw materials, particularly fresh dandang gendis leaves, and to allow sufficient time for each stage of the research process to be conducted without procedural overlap. Conducting the research within a continuous timeframe also minimized variability caused by seasonal changes or environmental fluctuations that could affect ingredient quality or product characteristics.

Research activities were carried out at two primary locations selected based on methodological considerations. Product formulation and preparation were conducted at the researcher's residence. This location was chosen due to its accessibility, availability of basic food processing equipment, and the ability to maintain close control over each step of the preparation process. Conducting the formulation process in a household environment also reflects real-world food preparation conditions, thereby enhancing the applicability of the findings to everyday contexts. Laboratory based analyses, particularly proximate analysis, were conducted at the laboratory of Universitas Brawijaya. This laboratory was selected due to its standardized facilities, availability of analytical equipment, and technical expertise required to produce accurate and reliable nutritional data.

The population of the study differed according to the stage of research. In the preliminary stage, the population consisted of dandang gendis leaves abundantly available around the researcher's residence. These leaves were selected as the population of interest because they represent locally sourced raw materials commonly used in traditional and functional food practices. In the main experimental stage, the population consisted of nursing students from the Health Polytechnic of the Ministry of Health Malang. This population was considered appropriate because of their basic familiarity with health-related concepts, their capacity to follow evaluation procedures, and their suitability as trained panelists for sensory assessment.

Sampling procedures were implemented in alignment with the objectives of each research stage. In the preliminary stage, purposive sampling was used to select dandang gendis leaves that met predefined quality criteria. Leaves were manually sorted to ensure uniformity in size, color, and maturity, while damaged or contaminated leaves were excluded. The selected leaves were separated from their stems and subjected to a drying process using a microwave at a temperature of 40°C. This drying method was chosen to reduce moisture content while minimizing potential degradation of bioactive compounds. After drying, the leaves were ground using a blender to obtain a fine and homogeneous powder suitable for incorporation into the product formulation.

The process of making Modified Cassava Flour (MOCAF) begins with selecting fresh cassava that is ripe for harvest (8–12 months), followed by peeling, washing, and slicing into thin chips approximately 1–1.5 mm. The main stage in MOCAF production is fermentation using agents such as Bimo-CF starter, lime water, yeast, enzymes, or Lactobacillus plantarum to modify the flour's physicochemical properties. After fermentation, the chips are drained, dried, milled to approximately 100 mesh, and packaged airtight, resulting in flour with distinct functional characteristics compared to tapioca or traditional cassava flour (Asmoro, 2021; Helilusiatiningsih, 2023; Hadistio et al., 2019)

The formulation process was conducted through a structured sequence of preparation and mixing to ensure consistency across samples. A measured amount of 300 grams of melted margarine was combined with 50 grams of palm sugar and mixed thoroughly until a uniform mixture was achieved. One egg was then added to the mixture and whisked until the batter became slightly expanded, indicating adequate incorporation of air. Dry ingredients were subsequently added in stages, consisting of 300 grams of Modified Cassava Flour (MOCAF), dandang gendis leaf extract powder, and soybean flour. Two distinct formulations were prepared to examine the effect of differing proportions of functional ingredients. Formulation F1 consisted of 40 grams of dandang gendis leaf extract and 80 grams of soybean flour, while formulation F2 consisted of 80 grams of dandang gendis leaf extract and 40 grams of soybean flour. The dough was shaped into small, uniform round portions to ensure even cooking. Prior to baking, the shaped dough was refrigerated for 30 minutes to stabilize texture and prevent excessive spreading during the baking process. Baking was performed using a microwave oven at a temperature of 100°C with both top and bottom heat applied for 50 minutes, resulting in cookies that were fully cooked and ready for evaluation.

In the main experimental stage, purposive sampling was again applied to select panelists for sensory evaluation. A total of 30 trained panelists were recruited based on specific inclusion criteria, including willingness to participate, ability to follow sensory evaluation instructions, and absence of allergies to the product ingredients. The number of panelists was determined to balance data reliability and feasibility, as sensory evaluation literature commonly recognizes 25–30 trained panelists as sufficient for obtaining consistent and representative results. All panelists evaluated both formulations under similar conditions to ensure comparability of responses.

Data collection was conducted using a combination of experimental observation, structured questionnaires, and laboratory analysis. Organoleptic testing was designed to assess the inherent sensory characteristics of the product, including taste, texture, color, and aroma. Panelists evaluated each attribute using a four-point scale, with higher scores indicating more favorable characteristics. Sample coding was applied to each formulation to prevent panelists from identifying the product formulation during evaluation, thereby reducing potential bias.

Hedonic testing was conducted to measure panelists' level of preference for each sensory attribute. A four-point hedonic scale ranging from "very dislike" to "very like" was used to capture panelists' acceptance of taste, texture, color, and aroma. This approach allowed the research to distinguish between objective sensory characteristics and subjective consumer preferences. Responses were collected using an online questionnaire platform to facilitate efficient data collection, storage, and processing.

Proximate analysis was conducted to determine the nutritional composition of the Gemoi Bite product. Laboratory analysis was carried out at Universitas Brawijaya using established analytical procedures to ensure accuracy and reproducibility. The results of proximate analysis provided quantitative data related to the nutritional profile of the product, supporting interpretation of its functional characteristics.

All data obtained from organoleptic and hedonic evaluations were compiled and analyzed systematically. Initial descriptive analysis was performed to summarize panelists' responses and identify overall trends. Statistical processing was conducted using SPSS software to support data interpretation and ensure consistency in analysis. The formulation that achieved the highest scores and overall acceptance was identified based on aggregated results. To enhance clarity and accessibility, data were presented in the form of tables and graphical representations, enabling readers to easily interpret and compare findings across formulations.

3. Results and Discussion

3.1 Research procedures

The research procedure in this study was designed as a systematic and structured sequence of activities aimed at obtaining the best possible formulation of Gemoi Bite as a functional food product. The procedure began with careful preparation of raw materials and equipment to ensure consistency and reproducibility throughout the research process. The main ingredients used in this study included dandang gendis leaf extract, soybean flour, mocaf flour, brown sugar, butter, and eggs, all of which were selected based on their functional, nutritional, and sensory characteristics. These ingredients were combined to produce a cookie product that balances palatability and health benefits.

The equipment used during the research process consisted of a stove, pan, digital scale, measuring cup, blender, spoon, whisk, thermometer, baking pan, and microwave. The selection of these tools was based on their suitability for small-scale food processing and their ability to support precise measurement and controlled processing conditions. Using standardized tools helped ensure uniformity across formulations and minimized variability in product quality.

In the preliminary research phase, two formulations were developed with different proportions of dandang gendis leaf extract and soybean flour to identify the most acceptable and functional combination. Formulation 1 (F1) consisted of 40 grams of dandang gendis leaf extract and 80 grams of soybean flour, while Formulation 2 (F2) consisted of 80 grams of dandang gendis leaf extract and 40 grams of soybean flour. Each formulation was produced into 30 cookie units to provide sufficient samples for sensory evaluation. These samples were distributed to panelists, and data were collected using a Google Form questionnaire as well as in-person interviews to capture more detailed qualitative feedback. The purpose of this phase was to evaluate organoleptic and hedonic aspects of the product based on four main indicators, namely color, aroma, taste, and texture. In the advanced research stage, the researcher selected 30 trained panelists from various classes within the nursing department of the Ministry of Health Polytechnic of Malang. These panelists were chosen due to their adequate knowledge, ability to follow evaluation instructions, and familiarity with health-related food products. Their involvement was essential in refining the formulation and ensuring that the evaluation results were reliable and representative.

3.2 Organoleptic test results

The organoleptic test was conducted to evaluate the sensory quality of Gemoi Bite products produced from the two different formulations. Sensory attributes assessed in this test included color, aroma, taste, and texture, as these characteristics play a critical role in determining consumer acceptance of food products. The results of the organoleptic test demonstrated clear differences between the two formulations.

Fig. 2. Gemoi Bite products

In terms of texture, the second formulation was described as crispy on the outside while remaining soft on the inside, a texture profile that is generally preferred in cookie products. The balance between crispness and softness contributed to a more pleasant mouthfeel compared to the first formulation, which tended to be softer and less crunchy. Aroma and taste evaluations also favored the second formulation, as panelists perceived a more balanced combination of dandang gendis leaf aroma and soybean flour flavor.

Table 1. Organoleptic test results

Formulation	Sweet and Flavored with Dandang Gendis Leaves and Soybean Flour	Light Brown Color	Soft Texture	Aroma of Dandang Gendis Leaves and Soybean Flour
Formulation 1	6.1	7.2	7.2	7.2
Formulation 2	8.1	8.2	8.2	8.2

In contrast, the first formulation was reported to have a less distinctive aroma and taste, with the soybean flour flavor being more dominant and less harmonious. These findings are summarized in Table 1, which presents the average scores obtained by each formulation for the evaluated organoleptic attributes. The consistently higher scores achieved by the second formulation indicate its superior sensory quality and justify its selection for further analysis.

3.3 Hedonic test results

The hedonic test was conducted to measure panelists' level of preference for each formulation. Unlike the organoleptic test, which focuses on sensory characteristics, the hedonic test emphasizes subjective acceptance and liking, reflecting potential consumer responses to the product. The results of the hedonic test showed that the second formulation was significantly more preferred by panelists compared to the first formulation. Scores for taste, color, texture, and aroma were consistently higher for the second formulation, indicating stronger overall acceptance. The data revealed that 15.25% of panelists expressed a clear preference for the second formulation, while only 2.5% favored the first formulation. This substantial difference highlights the impact of ingredient proportion on consumer acceptance.

Table 2. Hedonic test results

Formulation	Flavor	Colour	Texture	Aroma
Formulation 1	1.77	1.93	1.93	2.63
Formulation 2	3.47	3.07	3.13	3.30

Further analysis showed that the respondent acceptance rate reached 70% for the second formulation, compared to only 47% for the first formulation. This result confirms that the second formulation not only performed better in terms of sensory quality but also achieved broader acceptance among panelists. The alignment between organoleptic and hedonic test results strengthens the validity of the findings and supports the conclusion that the second formulation is more suitable as a functional snack product.

3.4 Proximate test results

Proximate analysis was conducted on the second formulation, which had demonstrated superior sensory quality and acceptance, to evaluate its nutritional composition. The results of the proximate test are presented in Table 3 and provide important insights into the product's nutritional value and functional potential. The analysis showed that the product contains a protein content of 6.7%, primarily derived from soybean flour. Protein plays a crucial role in maintaining metabolic balance and supporting insulin sensitivity, making it an important component for individuals with diabetes. The fat content was found to be very low at 0.35%, which supports the classification of the product as a low-fat snack suitable for individuals managing metabolic disorders.

Table 3. Proximate test results

Proximate Analysis	Value (Content)
Protein Content	6.7%
Fat Content	0.35%
Carbohydrate Content	78.5%
Moisture Content	10.81%
Ash Content	1.5%
Total Energy	256.5kal
Glycemic Index	37
Active Compounds:	
Flavonoids	0.2%
Isoflavins	0.1%
Saponins	0.1%

The carbohydrate content was relatively high at 78.5%, reflecting the presence of mocaf flour and other carbohydrate sources. However, these carbohydrates are predominantly complex carbohydrates, which are digested more slowly and help prevent rapid increases in blood glucose levels. The moisture content of 10.81% indicates good storage stability, as lower moisture levels reduce the risk of microbial growth and extend shelf life. The ash content of 1.5% suggests the presence of essential minerals that contribute to the overall nutritional quality of the product.

The total energy content was calculated at 256.5 calories per 100 grams, providing sufficient energy while remaining appropriate for controlled dietary intake. Importantly, the glycemic index of the product was measured at 37, classifying it as a low-glycemic-index food. This characteristic makes Gemoi Bite suitable for individuals with diabetes or those who need to maintain stable blood sugar levels. In addition to macronutrients, the product contains bioactive compounds, including flavonoids (0.2%), isoflavones (0.1%), and saponins (0.1%). These compounds are known for their antioxidant properties and their role in improving insulin sensitivity and reducing oxidative stress, further enhancing the functional value of the product.

3.5 Discussion

The findings of this study indicate that the development of Gemoi Bite as a functional cookie product successfully integrates sensory acceptability with nutritional and functional attributes. The overall results demonstrate that the formulation combining dandang gendis leaf extract, mocaf flour, and soybean flour can produce a snack product that is not only acceptable to consumers but also aligned with dietary needs, particularly for individuals with metabolic concerns such as diabetes mellitus. The discussion of these findings is essential to understand the implications of ingredient composition, processing methods, and sensory outcomes in the broader context of functional food development.

One of the most notable outcomes of this study is the clear difference in performance between the two formulations. The second formulation, which contained a higher proportion of dandang gendis leaf extract and a lower proportion of soybean flour, consistently demonstrated superior sensory quality and higher acceptance among panelists. This finding highlights the critical role of ingredient proportion in determining both the sensory and functional characteristics of a food product. Increasing the concentration of plant-based functional ingredients, when appropriately balanced, does not necessarily compromise palatability. Instead, it can enhance product appeal by contributing natural color, aroma, and flavor complexity.

The color of the second formulation was perceived as more attractive and natural due to the light brown appearance combined with a subtle green hue from the dandang gendis leaves. Color is often the first sensory attribute evaluated by consumers and plays a decisive role in initial acceptance. The natural coloration observed in this formulation may convey an impression of healthfulness and minimal processing, which is particularly important for functional food products targeting health-conscious consumers. This suggests that visual cues derived from natural ingredients can positively influence consumer perception even before taste evaluation occurs (Winarno, 2020).

Texture also emerged as a crucial determinant of acceptance. The balance between crispness and softness achieved in the second formulation reflects successful control of ingredient interaction and processing conditions. The use of mocaf flour contributed to structural integrity, while soybean flour and fat content influenced softness and mouthfeel. A desirable cookie texture not only enhances eating pleasure but also contributes to repeated consumption, which is essential for functional foods intended for long-term dietary use. The less favorable texture observed in the first formulation underscores the importance of optimizing ingredient ratios to achieve a harmonious physical structure.

Aroma and taste evaluations further reinforced the superiority of the second formulation. Panelists reported a more balanced and pleasant flavor profile, where the characteristic aroma of dandang gendis leaves complemented rather than dominated the overall taste. This balance is particularly important for products incorporating herbal ingredients, which can sometimes produce strong or unfamiliar flavors that limit consumer acceptance. The results suggest that careful formulation can mitigate these challenges and allow functional ingredients to be incorporated without reducing sensory appeal.

The hedonic test results provide additional insight into consumer acceptance. The significantly higher preference scores and acceptance rate for the second formulation indicate that sensory quality directly translates into liking and willingness to consume the product. The alignment between organoleptic and hedonic results strengthens the reliability of the findings, as both objective sensory assessment and subjective preference evaluation point to the same conclusion. This consistency suggests that the product formulation is robust in meeting consumer expectations.

From a nutritional perspective, the proximate analysis supports the classification of Gemoi Bite as a functional snack suitable for individuals managing blood glucose levels. The moderate protein content contributes to satiety and metabolic stability, while the low fat content aligns with dietary recommendations for metabolic health (Hermana, 2020). Although the carbohydrate content is relatively high, the nature of the carbohydrates, primarily derived from mocaf flour, contributes to a lower glycemic response (Lestari et al., 2023). The low glycemic index value observed in this product is particularly significant, as it indicates that the cookies are unlikely to cause rapid spikes in blood glucose levels when consumed in appropriate portions.

The presence of bioactive compounds such as flavonoids, isoflavones, and saponins further enhances the functional value of the product. These compounds contribute antioxidant activity and may support improved insulin sensitivity, reinforcing the role of Gemoi Bite as more than a conventional snack (Hosea et al., 2022). The incorporation of these bioactive components into a familiar food format such as cookies increases the likelihood of regular consumption, which is essential for achieving sustained health benefits (Han et al., 2021).

Processing methods used in this study also played a critical role in shaping product quality. The microwave drying technique applied to dandang gendis leaves was effective in reducing moisture content while preserving functional compounds. This method offers practical advantages in terms of efficiency, energy use, and accessibility, making it suitable for small-scale production. The baking process, including temperature control and resting time before baking, contributed to consistent texture and overall product stability (Handa & Hudha, 2022).

Beyond sensory and nutritional outcomes, the findings of this study have broader implications for functional food development and public health. The use of locally sourced ingredients such as dandang gendis leaves and mocaf flour supports food diversification and reduces dependence on imported raw materials. This approach aligns with sustainable food systems and promotes the utilization of indigenous resources that are culturally familiar and economically accessible.

Future development of Gemoi Bite could explore variations in formulation, such as adjusting sweetness levels, incorporating additional functional ingredients, or modifying processing techniques to enhance shelf life and sensory stability. Packaging and storage studies would also be valuable to assess product durability under different conditions. These steps would support the transition of the product from experimental development to practical application and commercialization.

In summary, the extended discussion of this study demonstrates that Gemoi Bite represents a promising functional food product that successfully combines sensory acceptability, nutritional adequacy, and functional potential. The findings underscore the importance of formulation optimization, processing control, and sensory evaluation in functional food development. By utilizing local ingredients and simple processing methods, this product offers a practical approach to addressing dietary needs while supporting sustainable food practices. The results of this study contribute valuable insights into the development of functional snacks and provide a foundation for further research and product innovation.

In addition to its classification as a functional food, Gemoi Bite can be scientifically positioned as a nutraceutical product, as it combines nutritional adequacy with bioactive compounds capable of exerting targeted physiological effects related to glycemic regulation. Nutraceuticals are defined as food-based products that provide health benefits beyond basic nutrition, including the prevention and management of chronic metabolic disorders such as diabetes mellitus. The formulation of Gemoi Bite, which integrates dandang gendis leaf extract, soybean flour, and mocaf flour, fulfills these criteria by delivering a synergistic combination of macronutrients and bioactive substances that collectively support blood glucose stabilization.

The inclusion of dandang gendis (*Clinacanthus nutans*) leaf extract plays a pivotal role in strengthening the nutraceutical profile of the product. This plant is widely reported to contain flavonoids, polyphenols, and other antioxidant compounds associated with antihyperglycemic and anti-inflammatory activities. Oxidative stress is a key factor in the pathogenesis of diabetes mellitus, contributing to insulin resistance and pancreatic β-cell dysfunction. Therefore, the antioxidant activity of dandang gendis leaf extract may help attenuate oxidative damage, improve insulin sensitivity, and support glucose homeostasis (Reviansyah, 2022). The application of microwave drying in this study further enhances the nutraceutical value by preserving thermolabile bioactive compounds while ensuring microbiological safety and product stability.

Soybean flour provides additional nutraceutical benefits through its high-quality plant protein and isoflavone content. Adequate protein intake is known to delay gastric emptying and reduce the rate of carbohydrate digestion and absorption, thereby attenuating postprandial glycemic responses. Isoflavones have also been associated with improved insulin sensitivity, anti-inflammatory effects, and modulation of lipid metabolism, all of which are relevant to diabetes management (Wagustina, 2021). The controlled proportion of soybean flour in Gemoi Bite allows these metabolic advantages to be achieved without negatively affecting sensory acceptance.

Furthermore, mocaf flour (modified cassava flour) serves as a carbohydrate source with favorable glycemic characteristics. Its higher resistant starch content slows enzymatic digestion in the small intestine, resulting in a gradual release of glucose into the bloodstream. This mechanism aligns with the low glycemic index observed in Gemoi Bite and supports its suitability for individuals with diabetes who require stable postprandial glucose levels. The combination of low–glycemic carbohydrates, plant protein, and antioxidants positions Gemoi Bite as a nutraceutical snack that addresses multiple metabolic pathways simultaneously.

From a safety standpoint, Gemoi Bite is formulated using natural, food-grade ingredients without synthetic additives, supporting its suitability for long-term consumption. When consumed in appropriate portions as part of a balanced diet, Gemoi

Bite can be considered a safe nutraceutical product that supports glycemic control and metabolic health in individuals with diabetes mellitus. Collectively, these findings reinforce the potential of Gemoi Bite as a locally sourced, science-based nutraceutical snack that integrates sensory acceptability with clinically relevant functional benefits.

The incorporation of *Clinacanthus nutans* (Dandang Gendis) Leaf Extract enriches Gemoi Bite with flavonoids, phenolics and other antioxidant phytochemicals known for glucose-regulatory and anti-inflammatory effect (Putri et al., 2023). For example, *Clinacanthus nutans* extracts significantly lower fasting blood glucose, suppress pro-inflammatory TNF-α, and raise antioxidant enzyme activity (superoxide dismutase) in diabetic model (Mustika et al., 2023). These bioactivities align with the pathophysiology of diabetes, in which oxidative stress drives insulin resistance and pancreatic β-cell damage (Putri et al., 2023). By neutralizing reactive oxygen species and attenuating inflammatory cytokines, the antioxidants in dandang gendis extract may protect β-cells and improve insulin sensitivity (Putri et al., 2023). Importantly, in our optimized Gemoi Bite formulation the measured active compounds include 0.2% flavonoids, 0.1% isoflavones, and 0.1% saponins, confirming that the product delivers these polyphenols in functional amounts. Furthermore, gentle microwave drying was used to process the mixture. Microwave heating dries volumetrically and rapidly, which has been shown to better preserve heat-labile antioxidants than slow hot-air methods. Indeed, prior work reports that microwave-dried herb, leaves often retain higher phenolic content and antioxidant capacity than conventionally dried samples, while also inactivating pathogens through rapid internal heating (Marques et al., 2025). Thus, microwave processing helps maintain *Clinacanthus nutans*' bioactivity in the final snack, without the nutrient loss or microbial risks associated with prolonged high-temperature drying.

Gemoi Bite's inclusion of defatted soybean flour adds a source of high-quality plant protein and soy isoflavones (e.g. genistein, daidzein). Dietary protein is well known to slow gastric emptying and blunt post-meal glucose spikes, partly by stimulating incretin hormones (GLP-1, GIP) that enhance insulin secretion (Kciuk et al., 2025). In practice, pre-meal protein "preloads" (even ~15 g) have been shown to reduce postprandial glycemia by delaying stomach emptying (Artati et al., 2023). Thus, the ~6.7% protein content of the optimized Gemoi Bite（from soy flour should modestly retard carbohydrate absorption and attenuate the postprandial blood glucose rise. Meanwhile, soy isoflavones contribute additional benefits for diabetes. Numerous studies report that genistein and related isoflavones improve insulin sensitivity and modulate lipid metabolism (Jain et al., 2022). For example, isoflavone supplementation has been associated with lower insulin resistance (HOMA-IR) and improved lipid profiles in diabetic subjects. Soy isoflavones also exhibit mild anti-inflammatory and antioxidant effects, further supporting metabolic health (Jain et al., 2022). In our Gemoi Bite formulation, isoflavone content was~0.1%, sufficient to elicit these modulatory effects without imparting strong flavor. Importantly, the soy addition was calibrated so as not to dominate taste: hedonic scores (color 8.2, taste 8.1, aroma 8.2, texture 8.2) were all high, indicating that the protein/isoflavone blend was well accepted.

The bulk carbohydrate in Gemoi Bite comes from mocaf flour – a fermented, modified cassava flour with enhanced fiber and resistant starch. Resistant starch (RS) is a portion of starch that resists enzymatic digestion in the small intestine, behaving similarly to fiber. Therefore the Resistant starch slows the rate and extent of glucose release into the bloodstream, reducing the insulin demand and lowering the food's glycemic index. In practice, foods rich in resistant starch produce smaller postprandial glucose excursions than high-glycemic staples. Cassava and mocaf in particular contain significant Resistant starch (often type-3 retrograded starch) and are known to have relatively low GI (Hariadi et al., 2023). In fact, prior data show mocaf flour has a glycemic index around 42. Consistent with this, the Gemoi Bite product itself was measured to have GI ≈37, a "low" value. This implies that its carbohydrates are released and absorbed gradually, as intended. The synergy of slow-digesting mocaf starch, soy protein, and antioxidants means Gemoi Bite engages multiple anti-diabetic pathways at once: it combines low-GI carbs (minimizing glucose influx) with nutrient signals (protein/amino acids) that temper glycemia and bioactives that mitigate oxidative damage and inflammation (Hariadi et al., 2023).

4. Conclusions

Based on the research results, the combination of dandang gendis leaf extract, mocaf flour, and soybean flour can produce functional cookies with good sensory characteristics and physiological benefits. The best formulation is found in the composition of 80 g of dandang gendis leaves and 40 g of soybean flour which is most preferred by panelists in terms of color, aroma, taste, and texture. The flavonoid content in dandang gendis acts as an antioxidant and stabilizes blood sugar, mocaf flour provides complex carbohydrates with a low glycemic index, while soybean flour enriches protein and supports glucose metabolism. This Gemoi Bite product is not only high in nutritional value, but also contributes to the achievement of SDGs point 3, namely a healthy and prosperous life by supporting healthy consumption patterns, preventing metabolic diseases, and improving community welfare through local functional food innovation. Gemoi Bite has the potential to be integrated into community-based diabetes prevention strategies led by local health authorities, including integration into the Posbindu PTM program, nutrition education initiatives, and healthy school canteen campaigns. Collaboration with local MSMEs and agricultural producers can ensure sustainable production and economic empowerment, while regulatory validation and product standardization will strengthen its scalability as a preventive public health intervention for type 2 diabetes.

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Author Contribution

Conceptualization, A.N.F.; Methodology, F.Z.B.; Software, F.Z.B.; Validation, A.N.F. and F.Z.B.; Formal Analysis, A.N.F.; Investigation, A.N.F, F.Z.B, and L.A.A.S.; Resources, L.A.A.S.; Data Curation, A.N.F.; Writing – Original Draft Preparation, A.N.F.; Writing – Review & Editing, A.N.F, F.Z.B, and L.A.A.S.; Visualization, L.A.A.S.; Supervision, S and A.N.F; Project Administration, F.Z.B and A.N.F.

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Ethical Review Board Statement

The study was conducted in approved by the Institutional Review Board (or Ethics Committee) of the Life Sciences Center Laboratory, Universitas Brawijaya (142/LSIH/EP/2025 and 28 July 2025).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Not available.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the author(s) used Grammarly to assist in improving grammar, clarity, and academic tone of the manuscript. After using this tool, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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