

Potato-Gorocho Banana Snack Bar as a Diabetes-Oriented Functional Snack Candidate: Proximate and Hedonic Evaluation

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ABSTRACT

The utilization of local food ingredients, such as gorocho banana (*Musa acuminata* sp.) and potato (*Solanum tuberosum*), may provide an opportunity to develop functional snack products with potential relevance for diabetes-oriented dietary management. However, the suitability of such products for individuals with diabetes mellitus requires further validation through glycemic index, glycemic load, dietary fiber, sugar profile, and postprandial glucose response analyses. This study aimed to formulate potato-gorocho banana snack bars and evaluate their proximate composition and consumer acceptance through hedonic testing. Based on the proximate analysis, the moisture content of F1, F2, and F3 did not exceed 13%, while the ash content remained below the commonly reported range for commercial snack bars. The fat content varied among formulations, with F3 showing the lowest value among the tested formulas. F1 showed the highest protein content at 8.36%, whereas F3 had the highest carbohydrate content at 53.83%. Hedonic evaluation showed differences in color, aroma, texture, taste, and overall acceptance among the formulations. F1 obtained the highest overall preference score compared with F2 and F3, indicating better consumer acceptance. Thus, F1 may be considered the most acceptable formulation based on proximate characteristics and hedonic preference. Nevertheless, this study was limited to proximate and hedonic evaluations; therefore, further assessment of glycemic index, glycemic load, dietary fiber, sugar profile, product stability, and postprandial glucose response is required before the product can be recommended for individuals with diabetes mellitus.



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Keywords:

Gorocho banana; Potato; Proximate analysis; Functional food; Hedonic test

Received:
2025-11-20

Accepted:
2026-06-16

Online:
2026-06-25

1. Introduction

Gorocho banana (*Musa acuminata* sp.) is a local plant widely found in North Sulawesi and has been empirically used as a food ingredient by communities, including individuals with diabetes mellitus [1]. Several studies have reported that gorocho banana

contains bioactive compounds, including phenolic compounds and antioxidants, which may contribute to its potential role in supporting health-oriented food development [1], [12]. The antioxidant activity of goroho banana is closely associated with its secondary metabolite content, particularly phenolic compounds, because these compounds are capable of scavenging free radicals and reducing oxidative stress. Kiay et al. (2019) also reported that goroho banana demonstrated antioxidant activity that may contribute to its biological potential [12].

The relevance of antioxidant-rich food ingredients in diabetes-related dietary management is related to the role of oxidative stress in the progression of diabetes complications. Diabetes mellitus is characterized by chronic hyperglycemia caused by disturbances in insulin secretion, insulin action, or both [25]. Persistent hyperglycemia may contribute to long-term complications involving several organs, including the eyes, kidneys, nerves, heart, and blood vessels [10]. In addition to glycemic control, adequate antioxidant intake has been suggested to help reduce oxidative stress, which is one of the mechanisms involved in diabetes-related complications [20]. Therefore, the development of food products containing local ingredients with potential antioxidant properties is relevant as a preliminary approach in designing functional food candidates. Potato (*Solanum tuberosum*) is also widely used as a food ingredient and industrial raw material because of its nutritional content and availability. Potatoes contain carbohydrates and other nutritional components that allow their use in various processed food products. Previous research has reported that potatoes may serve as an alternative carbohydrate source and have been studied in relation to glucose-related parameters [15]. In addition, potato peel extract has been reported to show antihyperglycemic potential in experimental models, indicating that potato-derived materials may contain bioactive compounds of interest [2]. However, the use of potato-based products for individuals with diabetes requires careful evaluation because carbohydrate content, glycemic index, glycemic load, dietary fiber, and sugar profile strongly influence postprandial glucose response.

The combination of goroho banana flour and potato starch may provide an opportunity to develop a local ingredient-based snack bar. Snack bars are practical food products because they are easy to consume, portable, and do not require special preparation before consumption [17]. For individuals requiring controlled dietary intake, snack products should ideally provide acceptable nutritional composition, consumer acceptability, and a controlled glycemic response. Ingredients used in diabetes-oriented snack development are expected to contain nutrients, adequate dietary fiber, and a favorable glycemic profile to help prevent excessive postprandial glucose elevation [5]. However, such claims must be supported by specific nutritional and physiological evaluations, including glycemic index, glycemic load, dietary fiber content, sugar profile, and postprandial glucose response.

Although several studies have explored local food ingredients as functional food components, the development of snack bars using goroho banana flour and potato starch remains limited, particularly in terms of proximate composition and consumer acceptance. Some functional food products have been developed without sufficient evaluation of nutritional content and sensory acceptability. Therefore, this study aimed to formulate potato-goroho banana snack bars and evaluate their proximate composition and consumer acceptance through hedonic testing. This study serves as a preliminary formulation evaluation; further studies on glycemic index, glycemic load, dietary fiber, sugar profile, and product stability are required before the snack bar can be recommended as a functional food product for individuals with diabetes mellitus.

2. Methods

Tools and Materials

The tools used in this research were a mixer, frying pan, knife, mold, basin scale, stove, oven, spatula, and baking paper. This research used two raw materials, namely potatoes and gorocho bananas, as well as other additional ingredients, namely margarine, stevia sugar, eggs, skim milk, and cashew nuts.

Making Gorocho Banana Flour

The gorocho bananas used are selected for their superior quality. They are peeled and washed under running water to remove any remaining sap. They are then drained and sliced thinly, similar to banana chips, to facilitate the drying process. They are then placed on a drying tray and placed in an oven at 50°C for 1 hour. The dried gorocho banana slices are then blended and sieved through a 60-mesh sieve. The gorocho banana flour is then stored in a tightly closed, airtight, dry container.

Formulation of Snack Bars

The snack bar formulations were developed by combining gorocho banana flour and potato starch with several supporting ingredients, including margarine, low-calorie sweetener, egg yolk, and skim milk. The three formulations were designed as independent formulation variants to evaluate differences in proximate composition and consumer acceptance. In this study, the total ingredient weight was not standardized among formulations because the amount of binding and fat-based ingredients, particularly margarine and egg yolk, was adjusted to obtain acceptable dough consistency, cohesiveness, molding ability, and baking characteristics. Therefore, the observed differences in proximate and hedonic properties should be interpreted as the combined effect of the overall formulation composition rather than solely the effect of gorocho banana flour and potato starch ratio.

Table 1. Formulation of snack bars containing gorocho banana flour and potato starch

No.	Ingredients	F1 (g)	F2 (g)	F3 (g)
1	Gorocho banana flour (<i>Musa acuminata</i> sp.)	50	100	130
2	Potato starch (<i>Solanum tuberosum</i> L.)	25	50	75
3	Margarine	40	100	80
4	Low-calorie sweetener (stevia)	3.6	3.6	3.6
5	Egg yolk	25	50	50
6	Skim milk	25	25	25
	Total formulation weight	168.6	328.6	363.6

Note: F1, F2, and F3 were formulated as independent formulation variants. The quantities of margarine and egg yolk were adjusted to support dough consistency, binding properties, and baking characteristics. Therefore, the results should be interpreted based on the overall formulation composition.

The preparation process began by weighing the required amount of gorocho banana flour, potato starch, and skim milk according to each formulation. The dry ingredients were mixed until homogeneous. Separately, margarine was melted over low heat, then mixed with stevia and egg yolk. The wet mixture was gradually incorporated into the dry mixture and mixed until a homogeneous dough was obtained. The dough was then shaped into rectangular bars on a baking tray lined with parchment paper. Roasted and coarsely ground cashew nuts were added as a topping. The snack bars were baked at 125°C for 50 minutes, cooled at room temperature, and cut into 2 cm pieces. The detailed formulation composition is presented in **Table 1**.

Hedonic Test

A hedonic test was conducted on 30 respondents. Respondents, in accordance with Research Ethics Committee No. 003565, used parameters tested, namely color, aroma, shape, texture, taste, and overall impression. This test was conducted on a 4-point hedonic scale: 1: dislike very much, 2: dislike, 3: like, 4: like very much, by looking at responses regarding the level of respondents' liking for the snack bar.

Statistical Analysis

Proximate data were analyzed descriptively based on the results obtained from laboratory testing. If replicate measurements were available, the data were expressed as mean \pm standard deviation and analyzed using one-way ANOVA followed by a post-hoc test. Hedonic data were analyzed using a non-parametric test because the hedonic scale is ordinal. If the same panelists evaluated all formulations, the Friedman test followed by post-hoc pairwise comparison was applied. A p-value of <0.05 was considered statistically significant.

3. Results and Discussion

The snack bars prepared from the three formulations had a similar physical appearance, namely brown stick-shaped bars with a length of approximately 2 cm. The proximate composition of the potato-gorocho banana snack bars was analyzed at BSPJI Manado. The evaluated parameters included moisture, ash, fat, protein, and carbohydrate contents. The results of the proximate analysis for each formulation are presented in **Table 2**.

Table 2. Proximate composition of potato-gorocho banana snack bars

No.	Parameter	Unit	F1	F2	F3	Test method
1	Moisture content	%	9.88	13.00	12.46	SNI 01-2891-1992, Clause 5.1
2	Ash content	%	1.84	1.86	1.73	SNI 01-2891-1992, Clause 6.1
3	Fat content	%	27.98	32.79	25.42	SNI 01-2891-1992, Clause 8.1
4	Protein content	%	8.36	7.63	6.56	SNI ISO 1871:2015
5	Carbohydrate content	%	51.94	44.60	53.83	IK-1.18, carbohydrate by calculation

Note: F1, F2, and F3 represent different snack bar formulations containing potato starch and gorocho banana flour. Carbohydrate content was determined by calculation.

Based on the proximate analysis, all snack bar formulations were evaluated using recognized standard methods, including SNI-based procedures for moisture, ash, and fat contents. The moisture content ranged from 9.88% to 13.00%, with the lowest value observed in F1 and the highest value observed in F2. These values were still within or at the maximum limit of the specification set by the Directorate of Nutrition, Ministry of Health of the Republic of Indonesia (2017), which states that the moisture content of snack products should not exceed 13%. Moisture content is an important quality parameter because it may influence texture, crispness, microbial stability, and product shelf life.

The ash content of the snack bars ranged from 1.73% to 1.86%, with the highest value found in F2 and the lowest value found in F3. These values were lower than the ash content range commonly reported for commercial snack bars, which is approximately 2.2%–2.5%. Ash content represents the inorganic residue remaining after high-temperature combustion and is commonly used as an indicator of the total mineral content in food ingredients [8]. The differences in ash content among formulations may be influenced by the variation in ingredient composition, including the proportion of

goroho banana flour, potato starch, skim milk, egg yolk, and other supporting ingredients.

The fat content varied among the formulations, with values of 27.98% in F1, 32.79% in F2, and 25.42% in F3. F3 showed the lowest fat content among the three formulations, whereas F2 showed the highest value. Therefore, the fat content should be interpreted cautiously and should not be described as low without comparison to a clear nutritional standard or similar commercial products. In general, fat content in snack bar products may be influenced by fat-containing ingredients such as margarine, egg yolk, milk components, and nuts. Kusumaningrum (2018) reported that lower fat content may contribute to a better snack bar formulation, depending on the intended nutritional profile. The Ministry of Health of the Republic of Indonesia (2018) also stated that the fat content of a food product is strongly influenced by the type and amount of ingredients used.

The protein content ranged from 6.56% to 8.36%, with F1 showing the highest protein content. The higher protein content in F1 may be related to the balance of ingredients in this formulation, including skim milk and egg yolk as protein-contributing components. However, because the total formulation weight and several supporting ingredients differed among F1, F2, and F3, the differences in protein content cannot be attributed solely to the concentration of potato starch and goroho banana flour. According to previous research [4], the composition and proportion of flour and other ingredients can influence the protein content of snack-based products.

The carbohydrate content ranged from 44.60% to 53.83%. F3 showed the highest carbohydrate content, followed by F1 and F2. This result is reasonable because potato starch and goroho banana flour are carbohydrate-rich ingredients. Andriyono et al. (2025) reported that starch-based food ingredients may contain high carbohydrate levels, depending on the type of raw material and formulation composition [4]. However, for products intended for diabetes-oriented dietary use, total carbohydrate content alone is not sufficient to determine suitability. Further evaluation of serving size, carbohydrate content per serving, dietary fiber, sugar profile, glycemic index, and glycemic load is required to support the potential use of this snack bar as a functional food product for individuals with diabetes mellitus.

The three snack bar formulations showed relatively similar physical characteristics in terms of shape and general appearance, as all products were prepared using similar processing methods and supporting ingredients. However, differences in the proportion of potato starch and goroho banana flour, as well as variations in other formulation components, may influence sensory attributes such as color, aroma, texture, taste, and overall acceptability. Therefore, a hedonic evaluation was conducted to determine consumer preference for each formulation, as presented in **Table 3**.

Table 3. Results of *Snack Bar* Hedonic Test Data Analysis

Formula	Color	Aroma	Texture	Taste	Overall	Statistical notation
F1	3.10	3.20	2.97	3.03	3.07 ± 0.086	a
F2	2.70	2.80	2.30	2.62	2.55 ± 0.224	b
F3	2.93	2.93	2.80	2.97	2.87 ± 0.113	ab

Note: Different letters indicate statistically significant differences among formulations based on the Friedman test followed by post-hoc pairwise comparison ($p < 0.05$).

Statistical analysis using the Friedman test showed a significant difference in hedonic preference among the three formulations ($p < 0.05$). Based on the hedonic evaluation, F1 obtained the highest overall preference score (3.07 ± 0.086), followed by

F3 (2.87 ± 0.113) and F2 (2.55 ± 0.224). These results indicate that F1 was the most acceptable formulation among respondents in terms of sensory characteristics, including color, aroma, texture, taste, and overall acceptance.

In terms of color, F1 obtained the highest score (3.10), indicating that respondents preferred the visual appearance of this formulation compared with F2 and F3. The brown color of F1 may be influenced by the combination of goroho banana flour and margarine during the baking process. Color is an important sensory attribute because it is often the first characteristic perceived by consumers and may strongly influence initial product acceptance. Based on research by Sari et al. (2021), color is the fastest sensory response and can easily create a positive impression. Food products with good taste, nutritional value, and texture may still be less preferred if their color is unattractive or deviates from consumer expectations.

The aroma attribute also showed the highest score in F1 (3.20), suggesting that this formulation produced a more acceptable aroma than the other formulations. The distinctive aroma of goroho banana flour may have contributed to the positive response of the respondents. Aroma is an important determinant of food acceptability because it can influence consumer perception before tasting the product. The aroma perceived by the nose is generally associated with several sensory impressions, including fragrant, sour, rancid, and burnt notes [26]. According to Kusumaningrum and Setiawan (2018), aroma testing is important because it can provide rapid information regarding consumer preference for a food product.

For texture, F1 also showed the highest score (2.97), indicating better textural acceptance compared with F2 and F3. According to Putri and Mardesci (2018), texture refers to the pressure sensation perceived in the mouth during biting, chewing, and swallowing, or through finger touch. The better texture acceptance of F1 may be related to its lower moisture content compared with F2, which can contribute to a firmer and less mushy snack bar structure. Amalia and Fizriani (2024) stated that increased water content in food products may reduce fracture strength and produce a softer texture. In addition, Widiawati et al. (2022) and Jauhariah (2013) reported that texture characteristics may be influenced by water content, binder composition, and the physical properties of the raw materials used. Therefore, the texture preference for F1 may be associated with the balance between goroho banana flour, potato starch, fat-based ingredients, and moisture content in the formulation.

Taste is one of the most important factors determining consumer acceptance of food products [14]. In this study, F1 obtained the highest taste score (3.03), indicating that respondents generally liked the taste of this formulation. The taste acceptance of F1 may be influenced by the characteristic flavor of goroho banana flour and the use of stevia as a low-calorie sweetener, which produced a taste that was not excessively sweet. This characteristic may be relevant for the development of snack products intended for diabetes-oriented dietary considerations. However, the claim regarding suitability for individuals with diabetes mellitus should be interpreted cautiously because this study did not evaluate glycemic index, glycemic load, dietary fiber content, sugar profile, or postprandial glucose response.

Overall, the hedonic evaluation showed that F1 was the most preferred formulation, with the highest scores for color, aroma, texture, taste, and overall acceptance. Nevertheless, the sensory superiority of F1 should be interpreted together with the proximate composition and the formulation design, because differences among formulas may also be influenced by variations in total ingredient weight and supporting ingredients. To strengthen the product's relevance for diabetes-related dietary use,

further studies are recommended to evaluate serving size, carbohydrate content per serving, glycemic index, glycemic load, dietary fiber content, sugar profile, and product stability.

This study was limited to proximate analysis and hedonic evaluation; therefore, the suitability of the snack bar for individuals with diabetes mellitus cannot yet be fully confirmed. The study did not assess glycemic index, glycemic load, dietary fiber content, sugar profile, or postprandial glucose response, which are essential parameters for diabetes-oriented food products. In addition, the total formulation weight and some supporting ingredients differed among F1, F2, and F3, which may influence both proximate composition and sensory acceptance. The hedonic test was also conducted on a limited number of respondents and did not specifically involve diabetic consumers. Further studies are needed to evaluate glycemic response, fiber and sugar composition, product stability, shelf life, and safety before this snack bar can be recommended as a functional food product for diabetes dietary management.

4. Conclusion

This study demonstrated that potato-gorocho banana snack bars have preliminary potential as locally based functional snack products. Based on proximate analysis, all formulations contained nutritional components, including carbohydrates, protein, fat, moisture, and ash. Among the three formulations, F1 showed the most favorable sensory acceptance, as indicated by the highest overall hedonic score compared with F2 and F3. These findings suggest that F1 may be considered the most acceptable formulation in terms of consumer preference and general proximate characteristics. However, the potential use of this snack bar as a diabetes-oriented functional food should be interpreted cautiously. This study was limited to proximate and hedonic evaluations and did not assess glycemic index, glycemic load, dietary fiber content, sugar profile, or postprandial glucose response. Therefore, further nutritional and physiological evaluations are required before this product can be recommended as a dietary alternative for individuals with diabetes mellitus.

Acknowledgements:

The authors sincerely thank the Association of Muhammadiyah and 'Aisyiyah Pharmaceutical Colleges (APTFMA) for the financial support provided for this research in 2025. The authors also appreciate the support and contribution of the research team and all parties involved in this study.

Conflicts of Interest:

The authors declare no conflict of interest regarding the publication of this paper.

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