Innovation of kwetiau with red rice and red bean flour: evaluation of nutritional value and potential fiber source for patients with diabetes mellitus

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Abstract

Diabetes mellitus is characterized by hyperglycemia and metabolic dysfunctions in carbohydrates, fats, and proteins, primarily due to impaired insulin action and/or secretion. Dietary fiber can help delay carbohydrates conversion to glucose, slow the rise in blood sugar, and aid in blood sugar regulation. This study aimed to evaluate the effects of red rice flour and red bean flour formulations on the sensory characteristics, fiber content, and nutritional value of kwetiau. The research utilized an experimental design with a completely randomized design (CRD) framework. Methodologies included hedonic tests to assess organoleptic properties, enzymatic gravimetry for fiber content, gravimetry for water and ash content, the Kjeldahl method for protein content, Soxhlet extraction for fat content, and calculations for carbohydrate and energy content. The formulations tested included F1 (80% red rice flour and 20% red bean flour), F2 (75% red rice flour and 25% red bean flour), and F3 (70% red rice flour and 30% red bean flour). Among these, F1 was identified as the most favorable. The Kruskal-Wallis test showed no significant differences in organoleptic properties such as color, aroma, taste, texture, and overall sensory acceptance. The nutritional analysis of F1 revealed a fiber content of 2.93%, water content of 67.2%, ash content of 0.43%, protein content of 1.98%, fat content of 2.45%, carbohydrate content of 27.9%, and energy content of 147.95 kcal per 100 grams. Future research should assess the efficacy of kwetiau, made with red rice and red bean flour, in managing diabetes mellitus.

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Introduction

Diabetes mellitus is characterized by hyperglycemia and metabolic dysfunctions in carbohydrates, fats, and proteins due to impaired insulin action and/or secretion. This condition can lead to both acute and chronic complications.[1,2] The International Diabetes Federation (IDF) reports that in 2021, the global prevalence of diabetes among people aged 20-79 was estimated at 10.5% (536.6 million people) and is projected to increase to 12.2% (783.2 million) by 2045.[3] This high prevalence ranks Indonesia as the country with the highest number of people with diabetes in the Association of Southeast Asian Nations (ASEAN) and 34th out of 204 countries globally.[4] Additionally, according to the World Health Organization (WHO), non-communicable diseases, including diabetes, account for 71% of deaths worldwide,[5] with an increasing number of adults suffering from diabetes, particularly in low- and middle-income countries.[6]

In Indonesia, non-communicable diseases are on the rise. The Indonesian Ministry of Health reported that the prevalence of non-communicable diseases reached 69.91% in 2019, with diabetes mellitus increasing from 6.9% to 8.5% from 2013 to 2018.[7,8] Indonesia currently ranks fourth among the top ten countries for diabetes mellitus prevalence, with 8.6% of its population affected by type 2 diabetes mellitus.[1] The high prevalence of type 2 diabetes mellitus is associated with unmodifiable risk factors such as age, gender, and genetics, as well as modifiable factors like smoking, diet, physical inactivity, and obesity.[10–14]

One preventive measure to manage blood sugar levels, particularly in people with type 2 diabetes mellitus, is to increase fiber intake.[15–17] Dietary fiber, especially soluble fiber, slows the absorption of carbohydrates, delays blood sugar spikes, and helps regulate blood sugar levels.[18–20] The Indonesian Society of

Endocrinology, or *Perkumpulan Endokrinologi Indonesia* (PERKENI) (2021), recommends a daily fiber intake of 20-35 grams, with an ideal intake of 25 grams for people with diabetes. Dietary fiber is classified as either soluble or insoluble.[21] Soluble fiber, which is water-soluble and passes undigested through the small intestine, is fermented by gut bacteria in the large intestine. Sources include pectin, gums, starches, oats, psyllium, fruits, vegetables, and legumes.[22,23] Soluble fiber can slow intestinal digestion, increase satiety, and prevent blood sugar spikes, reducing insulin demand.[24] Insoluble fiber, on the other hand, primarily aids in preventing digestive tract diseases, such as hemorrhoids and colon cancer.[24]

Red rice (*Oryza nivara*) is a staple food in Indonesia with high nutritional value. It contains carbohydrates, proteins, fats, minerals, fiber, and anthocyanins, which have antioxidant and anti-diabetic properties.[25] The fiber content in red rice (1.632%) is significantly higher than in white rice (0.5746%).[26] Red beans, another fiber-rich legume, are also low in fat, high in fiber, and have a low glycemic index, making them suitable for people with diabetes. Red beans are also an excellent source of high-quality protein.[27,28] Processing red rice and red beans into flour can increase their versatility and shelf life, making them ideal ingredients for various foods, including kwetiau.

Kwetiau is a popular noodle dish in Indonesia, typically made from rice flour. By substituting red rice and red bean flour for traditional rice flour, kwetiau can be made higher in fiber and, therefore, more suitable for people with diabetes.[6] This study aimed to develop a kwetiau product using red rice and red bean flour as an alternative high-fiber food for individuals with diabetes mellitus. Specifically, the study evaluated the sensory characteristics, fiber content, and nutritional value of kwetiau formulated with varying proportions of red rice and red bean flour.

Materials and Methods

Design, variable, materials

This study employed an experimental research method using a complete random design (CRD) with both independent and dependent variables. The independent variable was the formulation of red rice flour and red bean flour in the proportions of 80%:20%, 75%:25%, and 70%:30%, which influenced the dependent variables, specifically the organoleptic properties, including color, taste, aroma, texture, and overall impression, as well as fiber content and nutritional value.

The 80%:20% formulation of red rice flour and red bean flour was chosen for consumers who prefer a chewy texture similar to traditional kwetiau. The 75%:25% formulation balanced texture with nutritional enhancement, making it suitable for consumers who desire a more nutritious version of kwetiau while maintaining a familiar texture. The 70%:30% formulation, with its denser texture and pronounced red bean flavor, offered the highest nutritional value, which is ideal for consumers seeking a high-protein, high-fiber option.

The ingredients used to make kwetiau included red rice flour, red bean flour, white rice flour, tapioca flour, salt, and oil. The red rice flour was made from whole brown rice, which was dried and finely ground, while the red bean flour was produced from brownish-red beans that were dried and ground to a texture slightly coarser than that of white rice flour.

Instrument and data collection

The main research was conducted from January to February 2024, collecting data through organoleptic testing, fiber analysis, and proximate analysis for nutritional value. Organoleptic properties such as color, aroma, taste, texture, and overall impression were evaluated using hedonic tests rated on a scale of 1 to 7. The panel for the organoleptic test consisted of 30 semi-trained panelists, all students from the Nutrition Department at the Bandung Polytechnic of Health (Poltekkes Kemenkes Bandung) who met specific inclusion criteria: familiarity with organoleptic testing, interest in sensory evaluations, good physical health, absence of ENT issues or color blindness, and abstinence from coffee, tea, or milk two hours before and after testing. Panelists were also required to have no food allergies, especially to nuts, and to adhere to additional guidelines for testing, such as waiting at least 20 minutes after smoking or consuming certain foods. The selected panelists were level 2 and level 3 students who had received training in sensory evaluation. They were specifically trained to evaluate the sensory profile of kwetiau to ensure consistent judgments. Panelists were chosen based on availability, preference for kwetiau, frequency of kwetiau consumption (at least twice a week), high sensitivity to the tested product, and absence of smoking and illness history. Organoleptic testing followed specific procedures to ensure accuracy and consistency. First, kwetiau samples were prepared in uniform portions for each panelist, using standard containers to maintain consistency. Each sample was assigned an anonymous code to ensure blind testing. Samples were then served in random order to prevent sequence bias. Panelists used an evaluation sheet to rate various organoleptic parameters on a defined scale, such as taste, aroma, texture, and color. To prevent flavor carryover between samples, panelists were given water or white bread to cleanse their palate between tastings. The testing took place in a controlled environment, a specially designed Taste Test Laboratory, where factors such as lighting, temperature, and noise levels were carefully managed. Neutral lighting and a comfortable room temperature of 20-22°C were maintained, and each panelist sat in a separate booth to minimize distractions and reduce social influence. The panelists received training to standardize the evaluation process. First, they were introduced to the test's purpose, evaluation parameters, and the testing procedure. They were taught how to use the Likert scale for sensory intensity and provided with sensory descriptions, such as specific terms for taste (sweet, sour, bitter) and texture (crunchy, soft). Finally, panelists underwent retest exercises with similar samples to ensure they could provide consistent, standardized assessments. Fiber content testing was conducted at the Center for Standardization and Services of the Agro Industry using the enzymatic gravimetry method. Nutritional testing, which included moisture, ash, protein, fat, and carbohydrate content, was also performed at the same center. Energy content was calculated based on the Indonesian Food Composition Table.[29] The methods used included gravimetric analysis for moisture and ash content, the Kjeldahl method for protein content, the Soxhlet method for fat content, and calculation for carbohydrate and energy levels.

Analysis

The statistical analysis aimed to determine the effect of different formulations of red rice and red bean flour on the organoleptic properties of kwetiau. To test for normality, a Shapiro-Wilk test was conducted with a 95% confidence level (α=0.05). For normally distributed data, a one-way ANOVA was used; if significant ($p<\alpha$), a *post hoc* Tukey test was performed. For non-normally distributed data, the Kruskal-Wallis test was applied; if significant ($p<\alpha$), it was followed by the Mann-Whitney test.

Results

Product description

The red rice and red bean flour-based kwetiau is a modified version of traditional kwetiau, created as a fiber-rich food alternative for individuals with diabetes mellitus. This version is made by incorporating red rice flour and red bean flour. The preparation of the kwetiau involves two main steps: mixing the ingredients and steaming. The final product has a reddish hue, with the characteristic aroma of red rice flour and a subtle scent from the red bean flour. It offers a unique flavor profile with the red rice flour's distinctive taste, complemented by a mild aftertaste from the red bean flour and a slight saltiness from the added salt during preparation. The texture is chewy. The shelf life of this kwetiau is approximately three days at room temperature and up to four days if stored in a cool environment.

In the production process, yield calculations were conducted. Yield, an important parameter for evaluating a product's economic value and efficiency, is calculated based on the percentage of the ratio between the final and initial weights. A higher yield indicates greater economic and effectiveness value.[35] The yield for this kwetiau product was 95%, with an initial weight of 480 grams, which was reduced to 455 grams after steaming. Each serving of 100 grams of this kwetiau provides 11.72% of the daily recommended fiber intake for individuals with diabetes mellitus (Figure 1).

Organoleptic test

A hedonic test was conducted on three formulations with 30 trained panelists from Poltekkes Kemenkes Bandung to assess consumer acceptance of red rice and red bean flour kwetiau. Panelists preferred the first formula for color, the second for aroma and overall preference, and the third for taste. Texture was also rated highest for the first formula (Table 1). Average preference ratings for each attribute (color, aroma, taste, texture, and overall preference) are shown in Figure 2.

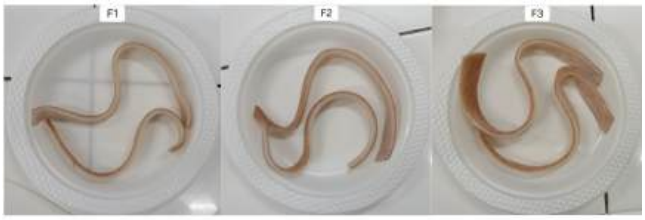

Figure 1. Formula 1 (F1), formula 2 (F2), formula 3 (F3) of kwetiau red rice flour and red bean flour.

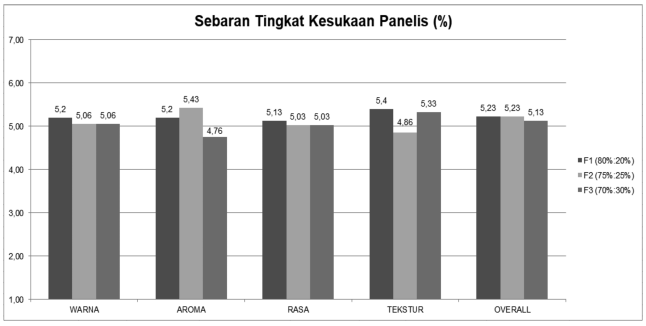

Figure 2. Average panelists' preference for color, aroma, taste, texture and overall kwetiau based on red rice flour and red bean flour.

Table 1. Distribution of panelists' preferences for color, aroma, taste, texture, and overall quality of kwetiau made with red rice flour and red bean flour.

Formula	Scale	Color		Aroma		Taste		Texture		Overall	
		n	%	n	%	n	%	n	%	n	%
1	Very dislike	0	0	0	0	1	3.3	0	0	0	0
	Dislike	0	0	1	3.3	0	0	0	0	0	0
	Somewhat dislike	2	6.7	1	3.3	1	3.3	2	6.7	2	6.7
	Neutral	8	26.7	9	30.0	8	26.7	5	16.7	8	26.7
	Somewhat like	5	16.7	3	10.0	7	23.3	7	23.3	6	20.0
	Like	12	40.0	12	40.0	8	26.7	11	36.7	9	30.0
	Very like	3	10.0	4	13.3	5	16.7	5	16.7	5	16.7
	Total	30	100	30	100	30	100	30	100	30	100
2	Very dislike	0	0	0	0	0	0	0	0	0	0
	Dislike	1	3.3	0	0	1	3.3	1	3.3	0	0
	Somewhat dislike	1	3.3	2	6.7	4	13.3	5	16.7	3	10.0
	Neutral	10	33.3	5	16.7	4	13.3	5	16.7	4	13.3
	Somewhat like	6	20.0	9	30.0	8	26.7	7	23.3	10	33.3
	Like	7	23.3	6	20.0	10	33.3	10	33.3	9	30.0
	Very like	5	16.7	8	26.7	3	10.0	2	6.7	4	13.3
	Total	30	100	30	100	30	100	30	100	30	100
3	Very dislike	0	0	0	0	0	0	0	0	0	0
	Dislike	0	0	0	0	1	3.3	1	3.3	0	0
	Somewhat dislike	3	10.0	7	23.3	3	10.0	1	3.3	3	10.0
	Neutral	9	30.0	6	20.0	4	13.3	5	16.7	6	20.0
	Somewhat like	6	20.0	6	20.0	10	33.3	8	26.7	8	26.7
	Like	7	23.3	9	30.0	10	33.3	10	33.3	10	33.3
	Very like	5	16.7	2	6.7	2	6.7	5	16.7	3	10.0
	Total	30	100	30	100	30	100	30	100	30	100

Color preference

The color of the first formula received the highest average preference, scoring 5.20. A Kruskal-Wallis test indicated no significant difference among the three formulas ($p=0.894 > \alpha=0.05$), meaning that color differences were not statistically significant. Therefore, a Mann-Whitney test was not applicable.

Aroma preference

The second formula was the most preferred in terms of aroma, with an average rating of 5.43. The Kruskal-Wallis test showed no significant difference among the formulas ($p=0.144 > \alpha=0.05$), so no further testing was conducted for this attribute.

Taste preference

The first formula scored highest in taste preference, with an average of 5.13. The Kruskal-Wallis test revealed no significant difference ($p=0.940 > \alpha=0.05$), indicating similar taste preferences across all formulations.

Texture preference

For texture, the first formula received the highest rating, averaging 5.40. The Kruskal-Wallis test showed no significant difference among the textures ($p=0.253 > \alpha=0.05$), so further testing was not required.

Overall preference

The second formula scored highest in overall preference, with an average of 5.23. The Kruskal-Wallis test indicated no significant differences in overall preference ($p=0.939 > \alpha=0.05$).

Fiber content

The fiber content test was conducted on the most preferred formulation. According to the panelists' feedback and preference ratings, the first formula, with a ratio of 80% red rice flour to 20% red bean flour, was selected for analysis. Fiber testing carried out at the Center for Standardization and Services of the Agro Industry used the enzymatic gravimetry method. The results indicated that this formulation contained 2.93% fiber, equivalent to 2.93 grams per 100 grams.

Comparison of fiber content with nutritional requirements

The fiber content of one 100-gram serving of the red rice and red bean flour-based kwetiau was 2.93 grams, which meets 11.72% of the daily recommended fiber intake for individuals with diabetes mellitus (25 grams/day).[3]

Proximate analysis (nutritional value)

The proximate analysis, which included measurements of water, ash, protein, fat, carbohydrate, and energy content, was conducted on the most preferred formula. Water and ash contents were determined by gravimetric methods, protein by the Kjeldahl method, fat by the Soxhlet method, and carbohydrate and energy content were calculated. Table 2 presents the results, indicating the following values per 100 grams: 67.2% moisture, 0.43% ash, 1.98% protein, 2.45% fat, 27.9% carbohydrates, and 147.95 kcal of energy. The data provide a comprehensive nutritional profile of the red rice and red bean flour-based kwetiau, highlighting its potential as a suitable dietary option for individuals with diabetes mellitus.

Testing of the energy, protein, fat, and carbohydrate content of kwetiau products made with red rice flour and red bean flour was conducted and compared with nutritional adequacy standards for these nutrients. The nutritional adequacy levels for energy, protein, fat, and carbohydrates are based on the recommended intake for snack foods as specified in the 2019 Nutritional Adequacy Figures (AKG).[30-32] The comparison of the energy, protein, fat, and carbohydrate levels in kwetiau products with red rice flour and red bean flour to nutritional adequacy can be seen in Table 3. Each 100-gram serving of this kwetiau provides 147.95 kcal of energy, 1.98 grams of protein, 2.45 grams of fat, and 27.9 grams of carbohydrates. Therefore, the nutritional adequacy per serving of kwetiau with red rice flour and red bean flour is as follows: 61.64% energy requirement, 31.68% protein requirement, 36.29% fat requirement, and 72.24% carbohydrate requirement.

Discussion

Organoleptic properties

All kwetiau formulas using red rice flour and red bean flour produce a red color. Across the three formulas, there were minimal color differences, as the flour ratios did not vary significantly. According to the organoleptic test results, the most preferred color was from formula 1, with an 80% red rice flour to 20% red bean flour ratio, where 16.7% of participants found it somewhat appealing, 40.0% liked it, and 10.0% liked it very much. Statistical analysis of the color aspect using the Kruskal-Wallis test found no significant effect of the flour ratios on the color of kwetiau products ($p=0.894 > \alpha=0.05$).

Table 2. Results of proximate analysis of kwetiau products based on red rice flour and red bean flour.

Nutrients	Result	Unit
Water	67.2	%
Ash	0.43	%
Protein	1.98	%
Fat	2.45	%
Carbohydrates	27.9	%
Energy	147.95	kcal/100 g

Table 3. Comparison of energy, protein, fat, and carbohydrate levels in kwetiau products made with red rice flour and red bean flour in relation to nutritional adequacy.

Nutrients	Nutritional value per serving	Nutritional adequacy	% Nutritional adequacy
Energy (kcal)	147.95	240	61.64%
Protein (g)	1.98	6.25	31.68%
Fat (g)	2.45	6.75	36.29%
Carbohydrates (g)	27.9	38.62	72.24%

The color produced from kwetiau products comes from red rice flour and red bean flour, both of which are red. This red color is due to the anthocyanin compounds found in red rice and kidney beans. The high and low pigment content will affect the color.[33,34] Winata and Yunianta explained that a higher anthocyanin content will increase the color of a product and will become redder.[35] Anthocyanin is one of the pigments commonly applied as a natural colorant in food.[36]

The aroma of the kwetiau formulas, typical of red rice with slight notes of red bean, was also not significantly different among the three formulations. The second formula, with 75% red rice flour and 25% red bean flour ratio, was the most preferred for aroma, with 30.0% of participants somewhat liking it, 20.0% liking it, and 26.7% liking it very much. The Kruskal-Wallis test found no significant effect of flour ratios on aroma ($p=0.144 > \alpha=0.05$). Setyaningsih *et al.* explain that aroma contributes to product appeal through volatile compounds, enhancing flavor and attractiveness.[37] Aroma serves to enhance the taste and increase the attractiveness of food products. The aroma produced in the kwetiau formula based on red rice flour and red bean flour is typical of brown rice flour and has a slight aroma from red bean flour. The difference in the aroma of kwetiau was minimal due to a slight variation in the balance ratio.

Taste can vary based on ingredients like red rice and red bean flour.[38,39] The flavors produced by the formulas reflect the distinct taste of red rice with a lingering aftertaste of red beans and a slight saltiness.[40] In the three formulas, taste differences were minimal due to similar flour ratios. Formula 3, with 70% red rice flour and 30% red bean flour ratio, was the most favored for taste, with 33.3% of participants somewhat liking it, 33.3% liking it, and 6.7% liking it very much. The Kruskal-Wallis test showed no significant effect of flour ratios on taste ($p=0.940 > \alpha=0.05$). Aulia *et al.* found similar results with red bean flour, observing no effect on the taste of cookies where other ingredients also influenced flavor.[41]

Texture significantly impacts product acceptance. In this case, the chewy texture of the *kwetiau* was primarily due to the inclusion of tapioca flour, a starch that increases water-binding capacity. Astuti (2009) noted that tapioca's high amylopectin content (83%) contributes to a chewy texture, as amylopectin traps water within starch granules, unlike amylose, which binds less water.[42] Imanningsih[43] explained that amylopectin, which branches and forms a double helix, makes water trapped in starch granules and is prevented from escaping, while amylose has a non-branching structure that makes amylose have a low ability to bind water, and water easily escapes.[28] The three formulas showed minimal texture differences due to the similar flour ratios. Formula 1, with an 80% red rice flour to 20% red bean flour ratio, was preferred for texture, with 23.3% of participants somewhat liking it, 36.7% liking it, and 16.7% liking it very much. The Kruskal-Wallis test indicated no significant impact of flour ratios on texture ($p=0.253 > \alpha=0.05$).

The overall acceptance aspect measures panelist preference across all sensory properties: color, aroma, taste, and texture. Since these aspects might yield different preferences, assessing overall acceptance helps determine the best product formulation. Formula 2, with a 75% red rice flour to 25% red bean flour ratio, achieved the highest overall preference, with 33.3% of participants slightly liking it, 30.0% liking it, and 13.3% liking it very much. The Kruskal-Wallis test showed no significant difference in overall acceptance across the three formulas ($p=0.939 > \alpha=0.05$). This lack of significant difference across sensory aspects may be due to the small variations in red rice and red bean flour ratios among the formulas. However, each formula had unique qualities: formula 1 (80:20) had a traditional chewy texture, formula 2 (75:25) offered a balanced texture and higher fiber content, and formula 3 (70:30) had a denser texture and stronger red bean flavor, ideal for consumers seeking higher protein and fiber content in kwetiau.

Proximate analysis (nutritional value)

The proximate analysis of kwetiau made from red rice and red bean flour was conducted to determine its nutritional composition, including protein, fat, carbohydrate, energy, moisture, and ash content. The protein content in kwetiau made from red rice and red bean flour was analyzed using the Kjeldahl method. Testing was conducted on the formulation with the best organoleptic properties, identified through a hedonic test as the 80% red rice flour and 20% red bean flour blend. This formulation yielded a protein content of 1.98 grams per 100 grams. The results suggest that increasing the proportion of red bean flour enhances the protein content of the kwetiau, due to the higher protein level in red beans. Fat content was measured using the Soxhlet extraction method on the same optimal formulation (80% red rice flour, 20% red bean flour). The fat content in this kwetiau formulation was found to be 2.45 grams per 100 grams. The carbohydrate content was calculated based on the measured protein, fat, moisture, and ash values. The formulation with superior organoleptic qualities (80% red rice flour, 20% red bean flour) contained 27.9 grams of carbohydrates per 100 grams. Energy content was estimated based on the Indonesian Food Composition Table (TKPI). The formulation tested (80% red rice flour, 20% red bean flour) was found to provide 147.95 kcal per 100 grams.

Water absorption capacity reflects the ability of the kwetiau to absorb and retain water, a quality influenced by protein properties. A high water absorption capacity facilitates starch gelatinization, resulting in a smooth, evenly steamed dough with no white or red spots.[32] The moisture content of the optimal formulation (80% red rice flour, 20% red bean flour) was measured at 67.2 grams per 100 grams. Increased red rice flour proportion was associated with lower water content due to the higher starch content in red rice. Conversely, higher red bean proportions raised the moisture content, likely due to the higher crude fiber content in red beans.[45]

Higher ash content in a food indicates a higher mineral content. The ash content for the preferred formulation (80% red rice flour, 20% red bean flour) was measured at 0.43 grams per 100 grams. During the ashing process, organic substances are burned away, leaving behind inorganic mineral elements. The findings suggest that increasing red bean flour raises the ash content, consistent with previous studies. For instance, Yanti found a positive correlation between mung bean additions and ash content in steamed sponge cakes.[46] Similarly, Arwin *et al.* noted that higher red bean proportions increased ash levels due to the high mineral content of red beans compared to red rice flour.[45]

Fiber content

The dietary fiber content in kwetiau made from red rice flour and red bean flour was analyzed for the formula with the most favorable organoleptic properties, as determined by a hedonic test. The chosen formula, with 80% red rice flour and 20% red bean flour ratio, was analyzed using an enzymatic gravimetric method. This method, widely used for dietary fiber analysis, involves hydrolyzing digestible carbohydrates, fats, and proteins using specific enzymes, followed by filtration to separate undigested residues as fiber. The residue is then dried, weighed, and further analyzed to account for any remaining protein and ash.[47] Despite its accuracy, the enzymatic gravimetric method is time-consuming and less practical due to the use of processed fiber, which can aid

in blood sugar regulation by slowing the conversion of carbohydrates to sugar, resulting in more stable blood glucose levels.[48-50] It functions by absorbing glucose, inhibiting enzymes, and enhancing the production of short-chain fatty acids by gut bacteria, aiding metabolism.[47]

Laboratory tests revealed that the dietary fiber content in kwetiau from red rice and red bean flour is 2.93 grams per 100 grams. A 100-gram serving of this kwetiau contributes approximately 11.72% of the recommended daily fiber intake for individuals with type 2 diabetes mellitus. The 2019 guidelines for managing type 2 diabetes recommend a daily fiber intake of 20-35 grams. Therefore, this dish could serve as a suitable snack or even a main course for those with type 2 diabetes, depending on portion size.[51] The development of kwetiau based on consumer sensory preferences provides valuable insight into the product's taste, aroma, texture, and appearance. Sensory testing also supports effective marketing strategies by highlighting the attributes that appeal most to consumers. This feedback is crucial for tailoring the product to meet market demands and consumer expectations. Overall, these findings benefit both consumers and the food industry. Consumers gain access to a healthier, higher-quality alternative. At the same time, the industry is presented with opportunities for innovation, enhanced regulatory compliance, and targeted marketing that aligns with current health trends in the food market.[48,52,53]

This study has limitations, particularly in the demographic diversity of the panelists, such as age, gender, cultural background, and dietary habits, which may influence the organoleptic assessment of kwetiau. Additionally, while the nutritional composition of the product was analyzed, its potential application as a dietary therapy for individuals with diabetes mellitus has not yet been explored, as the study focused solely on organoleptic properties and nutritional content without testing for anthocyanin levels.

Conclusions

No significant differences were observed in the organoleptic properties such as color, aroma, taste, texture, and overall acceptability of kwetiau made from red rice flour and peanut flour. Further research with different formulations and additional ingredient variations is recommended to address knowledge gaps and expand our understanding of kwetiau products. As this product has so far only been assessed for its organoleptic qualities and nutritional content, it has not yet been tested as an alternative food therapy for people with diabetes mellitus. Therefore, further studies are needed to evaluate the effectiveness of kwetiau products based on red rice and red bean flour for individuals with diabetes. Future research and development of kwetiau products could lead to practical applications that benefit society and inform policy or practice in related fields. It is also hoped that kwetiau products made from red rice flour and red bean flour will be recognized as a fiber-rich food source. Collaboration with households, the food industry, and commercial partners can help introduce these products to a broader audience.

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