

Development of fiber-rich cake based on mocaf and hunkwe flour for hypercholesterolemia prevention

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ABSTRACT

Hypercholesterolemia is a metabolic disorder characterized by high blood cholesterol levels and is often associated with low fiber intake. In Indonesia, the prevalence of hypercholesterolemia remains concerning, affecting approximately 30% of the population and increasing with age. One way to prevent this condition is to increase the consumption of high-fiber foods. Sponge cake made from mocaf and hunkwe flour is an alternative in the development of functional food products based on local ingredients. Mocaf and hunkwe flour contain high fiber, especially water-soluble fiber, which can help lower cholesterol levels through the mechanism of binding bile acids, increasing lipid excretion, and inhibiting fat absorption in the intestine. This research was conducted using a randomized block design (RBD) with a single factor and six different treatment combinations of mocaf flour and hunkwe rations (90:10, 80:20, 70:30, 60:40, 50:50, and 40:60), each with four replications. Fiber content was analyzed using an enzymatic-gravimetric method and statistically tested using ANOVA and DMRT. The findings indicated treatments had a significant difference ($p < 0.05$). The largest amount of fiber content was found in the 40:60 formulation ratio (5.83%), and the smallest was in the 90:10 ratio (4.83%). The results imply that a greater percentage of hunkwe flour increases the fiber content in the final product. This formulation shows potential for development into a functional food that helps prevent hypercholesterolemia.

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INTRODUCTION

Hypercholesterolemia is a metabolic disorder characterized by an increase in total cholesterol levels in the blood to above normal limits, namely above 200 mg/dL (Hadriyati *et al.*, 2023; Saputra & Lestari, 2025). The prevalence of hypercholesterolemia remains high worldwide, reaching 45%, 30% in Southeast Asia, and 30% in Indonesia. In Indonesia, 7.6% of the population has high total cholesterol levels (>240 mg/dL), and 21.2% are in the borderline or slightly high category (200-239

mg/dL) (Hadriyati *et al.*, 2023). Based on the Indonesian Health Survey (2023), the rate of hypercholesterolemia continues to increase with age. In the 15–24 age group, the prevalence is 2.8%, 7.8% for 25–34, 11.1% for 35–44, 17.5% for 45–54, and 21.2% for 55–64.

Apart from age, various other risk factors also play a role in increasing the prevalence of hypercholesterolemia, besides age, namely gender, family history, lack of physical activity, stress, and unhealthy eating patterns, especially foods high in fat and low in fiber (Nuranjumi & Wijaya, 2022; Zara & Afni, 2023). One major risk factor that is often overlooked is low fiber consumption. The average Indonesian fiber intake is approximately 10.5 grams per day, which is significantly below the recommended daily intake of 20–30 grams (Kemenkes RI, 2019; Purnamaningsih *et al.*, 2023; Siti *et al.*, 2019). Research by Yuliantini *et al.* (2015) indicates that total cholesterol levels will rise in proportion to the amount of fiber consumed.

Hypercholesterolemia is generally caused by elevated levels of LDL (*Low-Density Lipoprotein*) or bad cholesterol. Plaque can form on blood vessel walls as a result of elevated LDL levels. Atherosclerosis is the term for the constriction and hardening of the arteries brought on by plaque. The two biggest causes of death in the world, coronary heart disease and stroke, can be made more likely by atherosclerosis (Perkeni, 2021; Zara & Afni, 2023).

Efforts to prevent hypercholesterolemia can be done by adopting a healthy lifestyle, including regulating diet by increasing fiber intake (Layrenshia & Atzmardina, 2024). Functional foods are increasingly favored because considered safer and more natural than pharmacotherapy, which may cause side effects such as muscle pain, liver dysfunction, or gastrointestinal disorders (Cheon & Jo, 2022). Physical activity also plays a key role in cholesterol control, but it requires high commitment and discipline, which can be challenging to maintain over the long term. In this context, increasing the consumption of fiber-rich functional foods is a practical and sustainable alternative for the prevention and non-pharmacological management of hypercholesterolemia (Mutmainnah *et al.*, 2023). Dietary fiber, particularly the soluble type, plays a role in reducing and preventing elevated blood cholesterol by limiting its absorption in the intestines and promoting the excretion of bile acids (Fairudz & Nisa, 2015; Ghavami *et al.*, 2023). Therefore, fiber plays a crucial role in preventing cardiovascular disease related to cholesterol. One approach is to develop functional food products using local, fiber-rich ingredients, one of which is sponge cake. Sponge cake was chosen as the medium for functional food development due to its popularity and widespread consumption in Indonesia as a daily snack or dessert. Its soft texture and acceptability across all age groups make it a culturally relevant and practical choice for fiber enrichment (Pusungulena *et al.*, 2023). However, sponge cakes generally use wheat flour as the main ingredient, which is low in fiber. Therefore, it's necessary to add fiber-rich local foods like mocaf flour and hunkwe.

Modified cassava flour, or mocaf flour, is created from cassava by fermenting it with lactic acid bacteria such *Lactobacillus plantarum* (Asmoro, 2021). Mocaf flour has several advantages compared to wheat flour, including its high fiber content of 4.5% and its use in cassava butter (Yani & Akbar, 2018). Mocaf flour is also rich in vitamins, minerals, and resistant starch, which functions as a prebiotic that has the potential to lower cholesterol levels. Furthermore, the use of mocaf aims to reduce Indonesia's dependence on wheat (Ilham *et al.*, 2024; Widodo, 2023). However, mocaf flour has a high water absorption capacity, which affects the consistency of the dough, causing the dough to become denser and harder if not balanced with adjustments to the liquid or binding agent. (Dwipayanti *et al.*, 2022). Therefore, in sponge cake formulations, hunkwe flour is needed to improve the cake's soft texture. Furthermore, hunkwe flour also contains high fiber, 16.1 g per 100 g, which functions as a natural binding agent to reduce the texture of the final product and improve sensory quality (Kemenkes, 2017).

The fiber content in both flours can bind cholesterol and bile acids in the intestines, helping speed excretion through feces, and slow fat absorption, thereby preventing hypercholesterolemia. Several studies have shown that increasing fiber intake by 5–10 grams per day can lower LDL

levels by up to 5% (Nabila *et al.*, 2025). This study aimed to formulate sponge cakes made from mocaf and hunkwe flours and evaluate their fiber content. The results are expected to provide an important basis for developing functional products to support hypercholesterolemia prevention efforts and improve public health.

RESEARCH METHOD

The research method used was experimental with a one-factor randomized block design with variations in the ratio between mocaf and hunkwe flour. This study used six comparison treatments, namely 90:10, 80:20, 70:30, 60:40, 50:50, and 40:60. Each treatment was repeated four times, resulting in 24 samples. The materials used in this study were divided into two types, namely the main ingredients and the additional ingredients. The main ingredients include mocaf flour and hunkwe flour. The additional ingredients used include granulated sugar, eggs, canola oil, and chocolate. The analysis of dietary fiber chemicals used included phosphate buffer, HCl, petroleum ether, pepsin, ethanol, acetone, and the enzyme termamyl. The equipment used includes digital scales, mixers, baking pans, steamer pans, cake molds, analytical balances, 250 ml Erlenmeyer flasks, measuring cups, glass beakers, filter paper, cups, micropipettes, hot plates, aluminum foil, ovens, furnaces, water baths, and vacuum filtering devices.

This research is divided into 2 main stages, namely making sponge cake from mocaf and hunkwe flour, and analyzing the fiber content of the resulting cake. Making sponge cake begins by beating eggs and sugar using a mixer until the dough rises and is pale in color. Then, chocolate is melted with canola oil and mixed into the dough that has risen. A mixture of mocaf and hunkwe flour according to the formulation ratio is first mixed with cocoa powder, then added to the dough and stirred until homogeneous. The dough is poured into a cake mold that has been lined with baking paper. Next, the dough is steamed for \pm 30 minutes until cooked. After cooking, the cake is cooled at room temperature before being analyzed for fiber content.

Fiber content analysis was performed using an enzymatic gravimetric method consisting of several steps to remove non-fiber components such as starch, fat, and protein. The sample preparation began with drying and grinding, followed by extraction using petroleum ether (40 mL/g) for 15 minutes at room temperature. Subsequently, 1 gram of the sample was mixed with 25 mL of 0.1 M Na_2HPO_4 buffer (pH 6) and 0.1 mL of Termamyl enzyme, then incubated in a water bath at 100°C for 15 minutes to hydrolyze starch. After cooling, 20 mL of distilled water was added, and the pH was adjusted to 1.5 using HCl. Then, 100 mg of pepsin was introduced and the mixture was incubated at 40°C for 60 minutes. The digestion continued with the addition of 20 mL of water and pH adjustment to 6.8 using NaOH, followed by the addition of 100 mg of pancreatin and further incubation at the same temperature for another 60 minutes. The mixture was filtered through a crucible (porosity 2) containing 0.5 g of celite. The residue was sequentially rinsed with distilled water, 95% ethanol, and acetone. Finally, the residue was oven-dried at 105°C overnight, weighed, incinerated at 550°C for 5 hours, and reweighed to determine ash content. The filtrate obtained from the previous filtration was precipitated with warm 95% ethanol, filtered, washed, dried, and ashed to obtain the weight of soluble fiber. The blank value was obtained from the procedure without a sample. The fiber content was calculated from the difference between the residue and ash corrected with the blank.

The fiber content data were subjected to statistical analysis using One-Way ANOVA to evaluate the effect of varying ratios of mocaf flour and hunkwe flour on dietary fiber levels. When a significant difference was observed ($p < 0.05$), Duncan's Multiple Range Test (DMRT) was employed as a post-hoc analysis to identify specific differences among treatment groups.

RESULTS AND DISCUSSIONS

Fiber content analysis is a crucial aspect of food product quality. Fiber plays a role in lowering cholesterol levels and preventing hypercholesterolemia. Laboratory analysis revealed significant differences in fiber content between treatments in sponge cakes made from mocaf and hunkwe flour. The average fiber content values are shown in Figure 1 below:

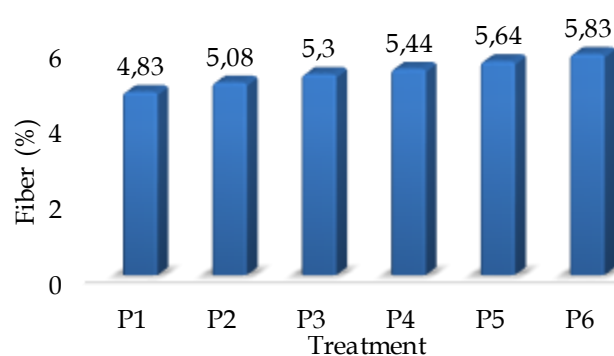


Figure 1. Average fiber graph of sponge cake based on mocaf and hunkwe flour

Based on the analysis results that can be seen in Figure 1, the highest fiber content was found in treatment P6, namely mocaf and hunkwe flour at 40:60, with a value of 5.83%, while the lowest fiber content was found in treatment P1 (90:10) at 4.83%. These results indicate that the increase in total fiber content is directly proportional to the increase in the ratio of hunkwe flour. The high fiber content in the formulation with a greater hunkwe ratio is due to hunkwe flour being known to contain 16.1 grams of fiber in 100 grams of material, much higher than mocaf flour, which only contains around 3.4 grams (Kemenkes, 2017).

The findings were validated through statistical analysis using One-Way ANOVA, which yielded a p-value of 0.001 (< 0.05), indicating that variations in the formulation of mocaf and hunkwe flours had a significant effect on the fiber content of the sponge cakes. To further identify specific differences between treatments, Duncan's Multiple Range Test (DMRT) was applied, as presented in Table 1.

Table 1. DMRT test results of sponge cake fiber content with mocaf and hunkwe flour variations

Treatment	Fiber (%)	DMRT Notation
P1 (90:10)	4.83 ± 0.02	a
P2 (80:20)	5.08 ± 0.03	b
P3 (70:30)	5.30 ± 0.04	c
P4 (60:40)	5.44 ± 0.02	d
P5 (50:50)	5.64 ± 0.04	e
P6 (40:60)	5.83 ± 0.02	f

Duncan's test results showed that each treatment had a different notation, indicating a significant difference between the treatments. The greater the amount of hunkwe flour used, the higher the dietary fiber content. This result supports the study's hypothesis that increased substitution with hunkwe flour enhances the functional fiber content of sponge cake, in line with previous research findings. Increasing fiber intake, especially soluble fiber, plays a key role in preventing high blood cholesterol levels and reducing the risk of cardiovascular disease (Bakr & Farag, 2023; Ghavami *et al.*, 2023). The soluble fiber contained in hunkwe flour works by binding bile acids in the small intestine. Bile acids are byproducts of cholesterol metabolism and are used in fat digestion. When fiber binds bile acids, increasing their excretion in the feces, the body reuses

cholesterol in the blood to synthesize new bile acids, thus lowering cholesterol levels (Deng *et al.*, 2023). Furthermore, the fermentation of soluble fiber by intestinal microbiota generates short-chain fatty acids (SCFAs), which play a role in suppressing hepatic cholesterol synthesis (Deng *et al.*, 2023; Park *et al.*, 2018). Besides hunkwe, fiber is also obtained from mocaf flour, although the fiber content is lower, namely 3.4% (Dwipayanti *et al.*, 2022). In addition, mocaf contains resistant starch, which also has a fiber effect in slowing digestion and improving gut health (Firdaus *et al.*, 2018). The combination of these two flours not only increases the fiber content in the cake but also serves as a functional snack that is beneficial in preventing hypercholesterolemia. This supports the aim of the study to develop a fiber-enriched food product as a preventive strategy for cholesterol-related health issues.

This study aligns with previous research on the potential of soluble fiber to lower blood cholesterol levels. (Fitriani & Setiarini, 2024) reported that mung bean starch, the main component of hunkwe flour, contains soluble fiber that can improve lipid profiles in test subjects. Similarly, Prita *et al.*, (2021) found that adding high-fiber flour to snack products not only enhances functional value but also remains acceptable to consumers. In addition, the findings of this study support those of Bakr & Farag (2023) who emphasized that dietary fiber from plant-based sources such as legumes plays a key role in regulating blood lipids through mechanisms such as bile acid binding and short-chain fatty acid (SCFA) production. The use of mocaf flour in functional food development is also beneficial, as it increases the content of both dietary fiber and resistant starch in cake products, thereby contributing to the prevention of hypercholesterolemia.

Although the fiber content of sponge cake ranges from 4.83% to 5.83%, this product still has the potential to be a fiber-rich snack. BPOM RI (2019) Regarding nutritional information, processed foods are considered a source of fiber if they contain at least 2.5 grams per serving. For a 50-gram portion of sponge cake, the highest fiber formulation, P5, would yield approximately 2.91 grams of fiber per serving, which meets the criteria for a fiber source. The average fiber consumption of Indonesians is currently very low, at 10.5 grams per day, far below the recommended daily intake of 25–35 grams (Prasetio, 2021). Therefore, the formulation of sponge cakes using mocaf and hunkwe flour can be a way to increase public intake through snacks. In addition to improving nutritional content, these products also offer health benefits, including preventing hypercholesterolemia and coronary heart disease.

CONCLUSION

From the results and discussion of this study, it may be concluded that the use of mocaf flour and hunkwe flour in making sponge cake has a considerable impact on increasing dietary fiber content. The dietary fiber content in the resulting brownies is in the range of 4.84% to 5.84%, indicating that the formulation with a combination of these two ingredients has the potential to produce a food product rich in fiber. The best treatment was obtained at a composition of the 60:40 ratio of mocaf to hunkwe flour (P6), with the highest fiber content of 5.84%. These results indicate that these two local ingredients can be used as an alternative to wheat flour in cake products to increase nutritional value, especially as a source of dietary fiber. This supports efforts to reduce dependency on imported wheat flour by promoting the use of local food sources such as cassava and mung bean starch in the food industry. Moreover, the cake produced from this formulation remained acceptable in terms of sensory attributes, indicating its potential for development as a functional food aimed at enhancing daily fiber intake. The development of sponge cake using mocaf and hunkwe flour not only contributes to improving public nutrition through increased fiber intake, but also supports local economic empowerment and food diversification efforts by utilizing domestic agricultural commodities. Further research is recommended to evaluate the clinical effects of this product on blood lipid profiles through human intervention studies.

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