

The Effect of Modified Kepok Banana (*Musa acuminata* × *balbisiana*) Starch Substitution on the Fat, Dietary Fiber, and Resistant Starch Content of Product Cookies [†]

Nain Azizah  and Aan Sofyan *

Nutrition Science Department, Muhammadiyah University of Surakarta, Jl. A. Yani Tromol Pos I, Pabelan, Kartasura 57169, Sukoharjo, Indonesia; j310211236@student.ums.ac.id

* Correspondence: aa122@ums.ac.id

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Abstract: Kepok banana can be used as a functional food ingredient. Efforts were made to improve the functional properties of Kepok banana starch by modifying it by autoclaving cooling. Modified banana starch can be combined with other flours in food products. The study objective was to determine the effect of modified Kepok banana starch substitution on the fat, dietary fiber, and resistant starch content of cooky products. The experimental design involved four treatments, which varied the percentage of modified banana starch substitution as follows: 0% (P0), 25% (P1), 50% (P2), and 75% (P3). Substitution with modified Kepok banana starch increased the fat, dietary fiber, and resistant starch content.

Keywords: cookies; modified starch; unripe Kepok banana; fat; dietary fiber; resistant starch



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1. Introduction

In Indonesia, the prevalence of diabetes mellitus is 1.5%, equivalent to 1,017,290 people [1]. Diabetes mellitus is classified into four types based on the cause, namely, type 1, type 2, gestational diabetes, and specific type diabetes [2]. Diabetes mellitus is a chronic metabolic disorder that occurs because the body does not produce enough insulin hormone or cannot use the insulin hormone to regulate glucose content in the body (insulin resistance) so that the glucose content in the body increases [3].

Insulin resistance in the body is caused by several factors, namely, obesity, unbalanced nutritional intake, lack of physical activity, genetic factors, and certain hormonal abnormalities [4]. Insulin resistance occurs due to changes in lifestyle and eating patterns that favor foods such as those that are high in energy, high in sugar, high in fat, have low fiber content, including instant or fast foods, which increase the blood glucose content [5,6]. Consumption of unbalanced diets that are maintained for a long time will cause insulin resistance and has triggered an increase in the prevalence of type 2 diabetes mellitus in Indonesia.

The right 3J diet (schedule, type, amount) is the key to maintaining stable blood glucose content in patients with type 2 diabetes mellitus [7]. The consumption of functional foods can contribute to the effective regulation of blood glucose content. Functional food is food that contains one or more compounds that have certain physiological functions that are beneficial for health and which do not cause side effects when consumed [8]. One type of local food that can be developed as a functional food to help regulate the diet is Kepok bananas.

Kepok bananas are a food ingredient that contain prebiotics. The types of prebiotics in Kepok bananas are inulin, oligosaccharides, and resistant starch. Resistant starch is starch that is resistant to being digested in the stomach and cannot be hydrolyzed by stomach

acid [9]. Resistant starch is resistant to digestive enzymes [10]. Resistant starch from the stomach in the small intestine is not absorbed until it goes to the large intestine and is fermented there by probiotic bacteria [11]. The fermentation of resistant starch that occurs in the large intestine produces short-chain fatty acids (SCFAs) [12].

The content of resistant starch contained in young yellow Kepok bananas is 27.7% [13]. Resistant starch as insoluble fiber helps lower cholesterol and to reduce the glycemic index. Resistant starch maintains the lipid profile by forming propionate from the fermentation of dietary fiber to reduce free fatty acids in the plasma and prevent gluconeogenesis. Resistant starch has the potential to control glycemia by reducing the rate of glucose absorption and increasing tissue sensitivity to insulin [14].

Fermented resistant starch in the large intestine produces short-chain fatty acids or SCFAs. SCFAs activate the GPR41 and GPR43 receptors identified as FF2 and FFA3, stimulating the secretion of hormones related to the insulin hormone, namely, the hormones glucagon-like peptide-1 (GLP-1) and peptide YY (PYY) [15]. The secretion of GLP-1 and PYY exerts beneficial effects on glucose metabolism and has the potential to release glucose-stimulated insulin hormone from pancreatic β -cells [16]. SCFAs are useful in managing the homeostasis of glucose by reducing glucose production and regulating insulin secretion [17]. The resistant starch content can have the effect of regulating insulin secretion if a minimum of 40 g/day is consumed [18].

Efforts to increase the content of resistant starch in prebiotic food sources include modification using the autoclaving–cooling method. The modified banana resistant starch content can be increased by 16.02% by carrying out three autoclaving–cooling cycles [19].

The fat content in Kepok bananas is 0.95% [20]. Type 2 diabetes mellitus sufferers have a tendency to dyslipidemia because the HbA1c content is related to lipid profile control [21]. There is, thus, a need to regulate fat intake to prevent an increase in the lipid profile. It has been found that making steamed bread by substituting Kepok banana flour can reduce the fat content of steamed bread [22].

Kepok bananas have a dietary fiber content of 7.77% [23]. Dietary fiber in the body absorbs water and binds glucose so that the blood glucose content can be controlled [24]. Providing a high-fiber diet to patients with type 2 diabetes mellitus can help control blood glucose content and improve insulin resistance [25]. In the making of muffins, the substitution of Kepok banana flour has a significant effect on the fiber content of the muffins [23]. Substitution of modified Kepok yellow banana flour in biscuits by 50% can increase the water content, starch digestibility, the resistant starch, and the total fiber of the biscuits [26].

Cookies are a food with a low water content and do not require a large expansion process when prepared. Cookies can be used as a snack for people with type 2 diabetes mellitus. Based on statistical survey data on food consumption in 2022, the average consumption of cookies is around 406 g per week [27].

The choice of Kepok bananas as a substitute material is suggested not only because they contain nutrients that are beneficial for diabetes mellitus sufferers, but also because of the characteristics of the starch produced. Kepok banana starch has advantages in terms of color, which tends to be bright white, and a soft starch texture, so that it can be used as an alternative or substitute ingredient for various food products [28].

Based on the above, we were interested in conducting research on the effect of modified Kepok banana starch substitution on the fat content, dietary fiber, and resistant starch of cookies.

2. Materials and Methods

2.1. Types and Research Design

The research undertaken was experimental, using a completely randomized design (CRD), with four treatments, namely, P0 (100% wheat flour and 0% modified Kepok banana starch), P1 (75% wheat flour and 25% modified Kepok banana starch), P2 (50% wheat flour and 50% modified Kepok banana starch), and P3 (25% wheat flour and 75% modified

Kepok banana starch). For each treatment, two repetitions of product manufacture and two repetitions of chemical quality analysis were carried out.

2.2. Time and Place of Research

The research was conducted from October 2022 to July 2023. The production of modified Kepok banana starch and the manufacture of cookies was carried out at the Food Science Laboratory, Nutrition Science Department, Muhammadiyah University, Surakarta. Testing for fat, dietary fiber, and resistant starch content was carried out at the Chemix Pratama laboratory, Yogyakarta.

2.3. Tools and Materials

Tools. The tools used in making modified Kepok banana starch were knives, trays, cutting boards, basins, blenders, baking sheets, food scales, filters, 100 mesh sieves, HDPE plastic, a cabinet dryer, an autoclave (brand My Life), and an oven. The tools used in the cooky manufacturing process were plates, spatulas, a mixer, spoons, cooky molds, and a baking tray.

Materials. The ingredients for making the modified Kepok banana starch were raw Kepok bananas with green and thick skin obtained from banana sellers at Kleco Market, Kartasura. The manufacturing materials included modified Kepok banana starch as a substitute ingredient, wheat flour, tapioca flour, margarine, eggs, powdered sugar, baking powder, skimmed milk, and water.

2.4. Research Stages

2.4.1. Process for Making Modified Kepok Banana Starch

Making the modified Kepok banana starch began with making Kepok banana starch. The stages are illustrated in Figures 1 and 2.

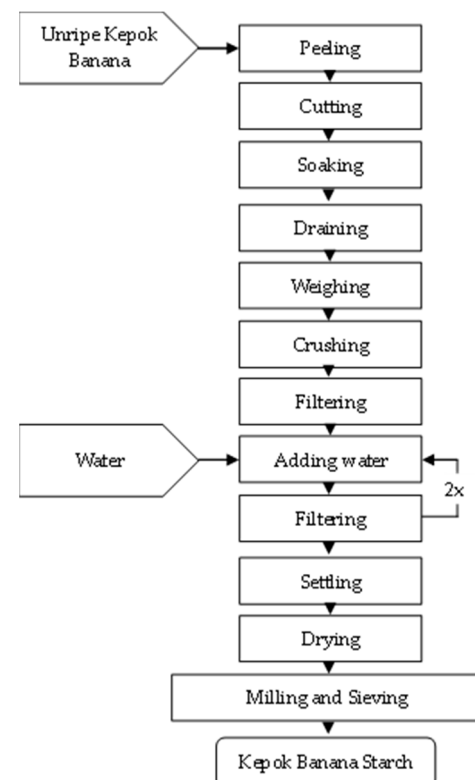


Figure 1. The stages of making Kepok banana starch.

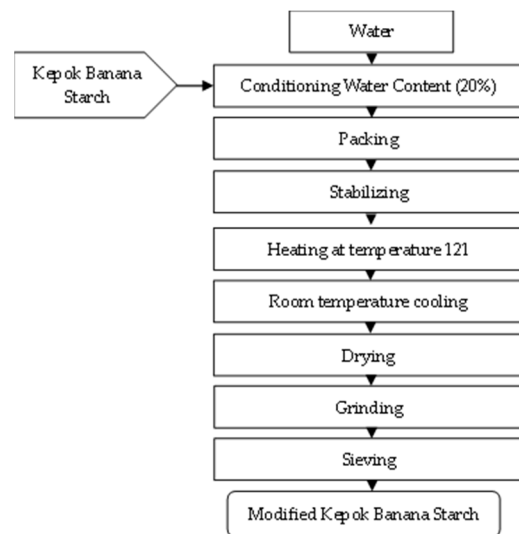


Figure 2. The stages of making modified Kepok banana starch.

2.4.2. Process of Making Cookies

The first stage in making cookies with modified Kepok banana starch substitution involved thorough mixing of all the ingredients used, including wheat flour, modified Kepok banana starch, tapioca flour, chicken eggs, margarine, powdered sugar, baking powder, and skimmed milk. Next, the cookies were molded (diameter 3 cm, thickness ± 0.5 cm) and baked in an oven at 150 °C for 15 min [29]. The ingredients of the cookies are displayed in Table 1 and examples of the cookies produced are shown in Figure 3.

Table 1. Composition of modified Kepok banana starch substitution cookies.

Materials	Composition (Grams)			
	P0	P1	P2	P3
flour	100	75	50	25
modified Kepok banana starch	0	25	50	75
tapioca flour	5	5	5	5
sugar	40	40	40	40
skimmed milk	10	10	10	10
egg	20	20	20	20
baking powder	1	1	1	1
salt	0.5	0.5	0.5	0.5
margarine	45	45	45	45
total	221.5	221.5	221.5	221.5



Figure 3. Cookies produced.

2.4.3. Testing

The fat content was tested using the Soxhlet method [30]. The dietary fiber content was tested using the enzymatic-gravimetric method [30]. The resistant starch content was tested using the enzymatic colorimetric method [31].

2.5. Statistical Analysis

The laboratory data for fat, dietary fiber, and resistant starch content were tested for normality using the Shapiro–Wilk test and then tested for homogeneity. Then, a one-way ANOVA was performed on the normally distributed test data. A Kruskal–Wallis test was performed instead if the test data were not normal.

3. Result and Discussion

3.1. Fat Content

The result of the Shapiro–Wilk test of normality for fat content was a p value of 0.134 ($p \geq 0.05$), which means that the fat content data for the cookies were normally distributed. The fat content data were tested statistically using one-way ANOVA. The results for the fat content tests are presented in Table 2.

Table 2. Results for the fat content of cookies.

Treatment	Fat Content	p Value
P0 (0%)	17.06 \pm 0.52 ^a	0.000
P1 (25%)	18.11 \pm 0.50 ^b	
P2 (50%)	19.19 \pm 0.14 ^c	
P3 (75%)	19.63 \pm 0.21 ^c	

The same letter indicates no significant effect on the DMRT test ($\alpha = 5\%$).

For the one-way ANOVA, a p value of 0.000 ($p \leq 0.05$) was obtained, which means there was an effect of modified Kepok banana starch substitution in the cookies on the fat content. The result of the fat content test was confirmed by the results of a DMRT test. Based on the test results presented in Table 2, the fat content in the cookies was in the range of 17.6–19.63%. The results of the fat content test suggest that as the percentage of modified Kepok banana starch substitution increased, the fat content in the cookies increased also.

This is because the fat content of Kepok banana starch is 0.06% [32] and the fat content of wheat flour is 1% [33]. The percentage of modified Kepok banana starch substitution increased with decrease in the percentage of wheat flour in the product. The fat content in the wheat flour was higher than the fat content in the modified Kepok banana starch.

The results obtained were different from the previous results of research on making biscuits by substituting Kepok banana flour [34]. The results of this study did not show a significant difference in fat content. Moreover, the substitution of Kepok banana flour in making snack bars was not found to have a significant effect on the fat content of snack bar products [35].

The test results for the fat content cookies met the minimum fat requirements based on the quality requirements for cookies of 9.5% per 100 g cookies [36]. The fat content of cookies with substitution of modified Kepok banana starch did not meet the special requirements as processed food for special medical purposes (PKMK) for diabetes mellitus sufferers. Based on the PKMK regulations for people with diabetes mellitus, the fat content required in PKMK products is around 20–25% of the total daily calories [37]. The fat requirements are 20–25% of total calories a day for someone consuming 2150 kcal, or 12–15 g per day. Based on these regulations, cookies made with modified Kepok banana starch substitution cannot be used as a snack for people with diabetes mellitus.

3.2. Dietary Fiber

The result of the Shapiro–Wilk test of normality on dietary fiber content was a p value of 0.021 ($p \leq 0.05$), which means that the data on the dietary fiber content of the cookies

were not normally distributed. The dietary fiber content data were then tested statistically using the Kruskal–Wallis test. The results of the dietary fiber content test are presented in Table 3.

Table 3. Results of the dietary fiber content of cookies.

Treatment	Dietary Fiber Content	<i>p</i> Value
P0 (0%)	9.75 ± 0.10 ^a	0.003
P1 (25%)	11.83 ± 0.58 ^{ab}	
P2 (50%)	13.48 ± 0.45 ^{ab}	
P3 (75%)	14.30 ± 0.04 ^b	

The same letter indicates no significant effect on Dunnett's test ($\alpha = 5\%$).

The test result for dietary fiber content was a *p* value of 0.003 ($p \leq 0.05$), which means that there was an effect of substitution of modified Kepok banana starch on the dietary fiber content of cookies. Therefore, the results were tested further using Dunnett's test. The result of the Dunnett's test presented in Table 3 show that there was a significant difference in the dietary fiber content between treatments P0 and P3; apart from these treatments, there was no significant difference in the observed content of dietary fiber in the cookies.

Based on the results presented in Table 3, the dietary fiber content of cookies was in the range of 9.75–14.30%. The higher the percentage of modified Kepok banana starch substitution, the higher the dietary fiber content of the cookies. The increase in dietary fiber content of the cookies occurred because the crude fiber content in yellow Kepok bananas is 1.14% [20]. Furthermore, the dietary fiber content in Kepok banana flour is 10.22% [22], while the dietary fiber content in wheat flour is 0.03% [33].

The research results obtained are in line with previous research on the substitution of Kepok banana flour in steamed sponge cake, which showed an effect on the fiber content of the product [38]. Moreover, in the making of kabosol, it was found that the greater the percentage of substitution of modified Kepok banana flour, the more the dietary fiber content in the product increased, with 100% substitution of modified Kepok banana flour resulting in a dietary fiber content of 20.65% [39]. Replacing wheat flour with Kepok banana flour in the process of making steamed bread improved the dietary fiber content in the product from 3.57% to 13.66% [22].

The results of the dietary fiber content tests on the cookies with the substitution of modified Kepok banana starch are in accordance with the regulatory requirements for dietary fiber quality. The dietary fiber quality requirements based on the BPOM RI regulations are a minimum of 3% per 100 g of cookies. Cookies produced using substitution with modified Kepok banana starch can be recommended as a snack source of fiber because the dietary fiber contents were found to be above the minimum required.

3.3. Resistant Starch

The results for the normality test for the resistant starch content of cookies was a *p* value of 0.189 ($p \geq 0.05$), which means that the data were normally distributed. Therefore, the data on the resistant starch content were tested statistically using one-way ANOVA. The results of the fat content test are presented in Table 4.

Table 4. Results of the resistant starch contents of cookies.

Treatment	Resistant Starch Content	<i>p</i> Value
P0 (0%)	8.12 ± 0.48 ^a	0.000
P1 (25%)	9.76 ± 0.66 ^b	
P2 (50%)	10.88 ± 0.55 ^c	
P3 (75%)	11.84 ± 0.36 ^d	

The same letter indicates no significant effect on the DMRT test ($\alpha = 5\%$).

The one-way ANOVA produced a p value of 0.000 ($p \leq 0.05$), which means that there was an effect of substitution of modified Kepok banana starch on the resistant starch content of cookies. DMRT tests were also carried out. The DMRT test results presented in Table 4 show that there were significant differences in the resistant starch content between the treatments.

Based on the research results in Table 4, it was observed that the higher the percentage of modified Kepok banana starch substitution, the higher was the resistant starch content of the cookies. The range of resistant starch content values for the cookies was 8.12–11.84%. The increased content of resistant starch arises because the resistant starch content of Kepok bananas is 27.7% [13].

The results of this research are in line with the findings of research on the manufacture of cookies showing that the substitution of modified Kepok banana flour and green bean flour had an effect on the resistant starch contents of cookies, with an increase in the resistant starch content with each treatment [40]. The substitution of Kepok banana flour in product cookies has been shown to have a significant effect on the resistant starch content of cookies [39]. Further, in the process of making steamed bread, replacing wheat flour with 100% Kepok banana flour can improve the resistant starch content in the product from 2.1% to 13.02% [22].

4. Conclusions

The results of this study show that there was an effect of Kepok banana starch substitution on the fat content ($p = 0.000$), dietary fiber ($p = 0.003$), and resistant starch ($p = 0.000$) of cookies. The greater the percentage of modified Kepok banana starch that was substituted in the product cookies, the higher the fat content, the dietary fiber content, and the resistant starch content of the product. The treatment with the highest fat content, dietary fiber content, and resistant starch content was 75% modified Kepok banana starch substitution, associated with the highest fat content of 19.63%, a dietary fiber content value of 14.30%, and the highest resistant starch content of 11.84%. In future research the fat, dietary fiber, and resistant starch content in modified Kepok banana starch should be tested. Further research is needed on the substitution of Kepok banana starch in cookies using special sugar for diabetes mellitus sufferers. Research is also needed to analyze the fat content of product cookies with the substitution of modified Kepok banana starch as a processed food product for special medical purposes (PKMK) for diabetes mellitus sufferers.

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