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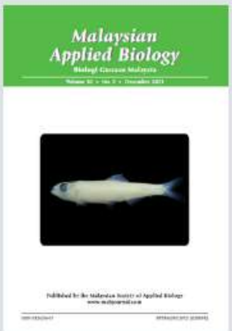

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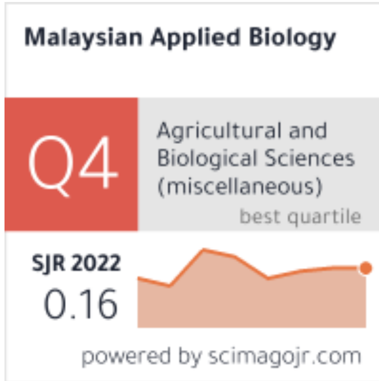

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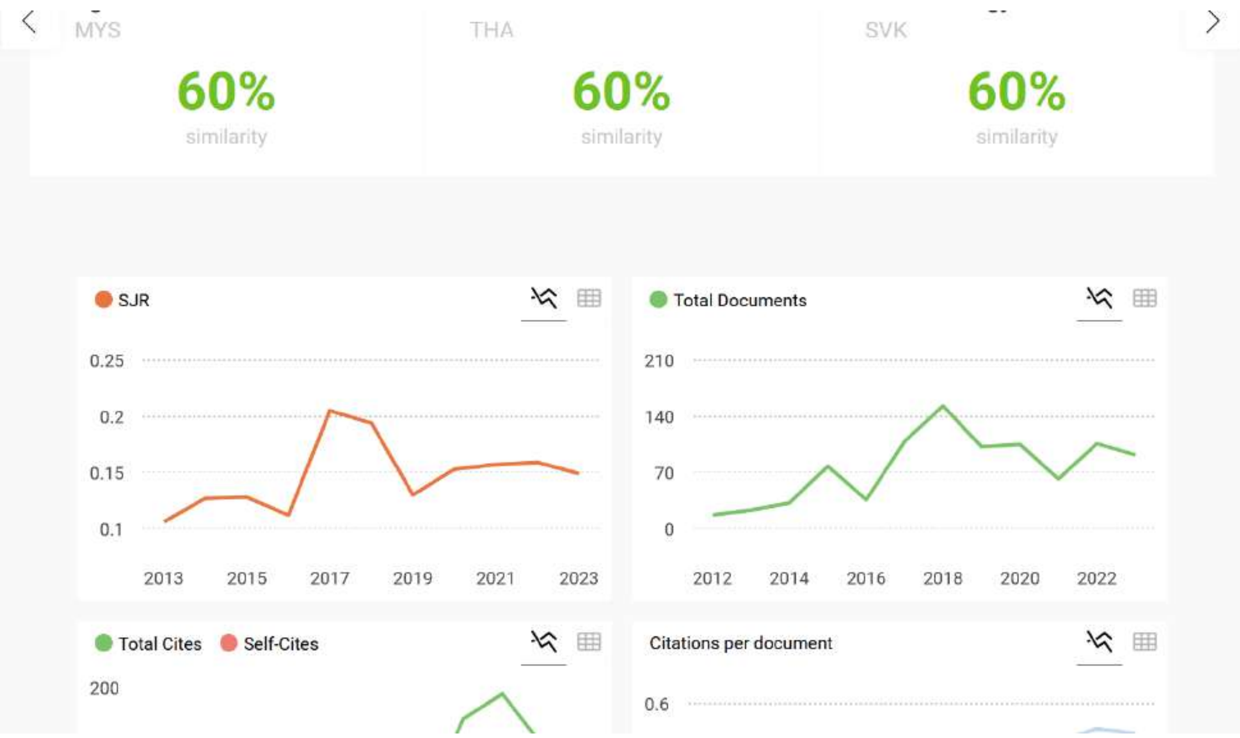
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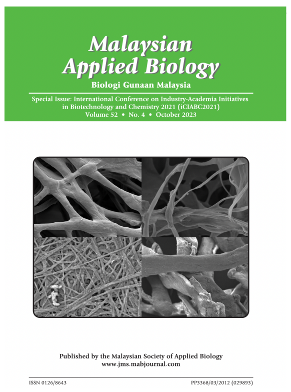

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Faculty of Science and Technology, UKM
43600 Bangi, Selangor, MALAYSIA
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Research

Development of Low Glycemic Index Cookies Made From Functional Cassava Pulp Flour

Beni Hidayat[1]*, Udin Hasanudin[2], Siti Nurdjanah[2], Neti Yuliana[2] and Zukryandry[1]

1. Department of Agricultural Technology, Lampung State Polytechnic, Lampung 35144, Indonesia
2. Department of Agricutural Product Technology, Lampung University, Lampung 35145, Indonesia

*Corresponding author: beni_lpg@polinela.ac.id

ABSTRACT

One of the food ingredients with the potential to be used as raw material for low glycemic index food is functional cassava pulp flour (FCPF) which has a dietary fiber content of 23.84% and resistant starch of 7.31%. The present research aimed to obtain the optimal substitution concentration of FCPF to produce cookies with the best nutritional, organoleptic, and physical characteristics and a low glycemic index. It was arranged in a Completely Randomized Design (CRD) with six levels of substitution concentration of FCPF, namely, 0% (control), 10%, 20%, 30%, 40%, and 50%. The results showed that the higher the concentration of FCPF substitution, the higher the fiber content, the resistant starch content, and the texture of cookies. Cookies with a 50% FCPF substitute concentration have the same organoleptic quality as those made from wheat flour (6.6 versus 6.9) but with the lowest glycemic index (40.29%). Cookie products with a 50% FCPF formulation are categorized as foods with a low glycemic index.

Key words: Cookies, functional cassava pulp flour, glycemic index

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INTRODUCTION

The biggest issue with the Indonesian diet is the lack of food with a low glycemic index, as rice, the country's common cuisine, has a high glycemic index (Foster-Powell *et al*., 2002). One of the food ingredients that have the potential to be used as raw material for low glycemic index food products is functional cassava pulp flour which has a food fiber content of 23.84% and resistant starch of 7.31% (Hidayat *et al*., 2021). According to Raigond *et al*. (2014), the content of dietary fiber and resistant starch is one of the indicators to classify a food product as a functional food. A portion of food can be categorized as a source of dietary fiber if it contains minimal dietary fiber 3% and as high-fiber food if it contains minimal dietary fiber 6% (CAC, 2009). In general, a high content of dietary fiber and resistant starch will contribute to a low glycemic index value of a food product (Zhang *et al*., 2007; Trinidad *et al*., 2010).

Functional cassava pulp flour is a composite flour consisting of a mixture of fermented pulp flour (82.64%), starch (17.54%), and xanthan gum (0.10%) (Hidayat *et al*., 2020). To improve its characteristics as a functional food, the resistant starch content of functional pulp cassava flour was increased through a two-cycle heating-cooling process under partial gelatinization conditions (Hidayat *et al*., 2021). The resistant starch found in functional cassava pulp flour is of type 3 which is formed as a result of the retrogradation process. According to Gallant *et al*. (1992) and Buleon *et al*. (1998), resistant starch is difficult to hydrolyze by amylolytic enzymes so it will reduce the digestibility of starch and lower the glycemic index of a food ingredient. A contraction in starch digestibility along with an increase in the content of resistant starch was also reported by Chung *et al*. (2006), Mir *et al*. (2013), and Zhu *et al*. (2011).

Some of the advantages of functional cassava pulp flour as a raw material for food products with a low glycemic index are the following. (1) It does not affect the economy because it uses cassava pulp as raw material, (2) it has a high protein content and low cyanide content due to a semisolid fermentation process, (3) it has a high content of dietary fiber and resistant starch, and (4) the content of resistant starch of type 3 does not cause significant changes in the texture of food products (Homayouni *et al*., 2014).

The diet of people with diabetes mellitus, which consists of small and frequent meals but can still contribute to nutritional adequacy, is typically taken into account when creating food high in dietary fiber and resistant starch in the form of snacks. The development of high-fiber food products, among others, is performed in the form of crackers (Nawansih *et al*., 2020), muffins (Nurdjanah *et al*., 2017), breakfast fiber cereals (Hlebowicz *et al*., 2007), barley breakfast cereal (Rendel *et al*., 2005), *cookies* from endocarp flour (Becker *et al*., 2014), and *cookies* from blackcurrant flour and whole grain flour (Hossain *et al*., 2017). Additionally, the development of food products high in resistant starch, among others, is executed in the form of banana starch cookies (Bello-Perez *et al*., 2004; Aparicio-Saguila'n *et al*., 2007). Of all these food products, cookies are the most popular snack products in the community.

One of the important factors studied in the formulation of food products high in dietary fiber and resistant starch is consumer acceptance considering that there is a tendency for the products produced to be hard textured (Hidayat *et al*., 2018). Therefore, it is necessary to have the right formulation so that the resulting cookie products have a low glycemic index value but still have high consumer acceptance. This research aimed to obtain the optimal formulation of functional cassava flour to get cookie products with the best properties including nutritional composition, sensory qualities, physical qualities, and low glycemic index values.

MATERIALS AND METHODS

This study was carried out at the Agricultural Product Technology Laboratory, Analysis Laboratory, Polyclinic Lampung State Polytechnic, and Integrated Laboratory Tanjung Karang Health Polytechnic from July 2020 to November 2020. The composition of functional cassava flour is the focus of this study as presented in Table 1. Ingredients for making cookies (Bogasari low protein flour, Maizenaku cornflour, Indomilk milk powder, Anchor butter, Ratu refined sugar, Daun salt, Koepoe-Koepoe vanilla powder & baking powder, & egg yolks that are collected from Chandra Supermarket Bandar Lampung) and chemicals for testing product characteristics were attained from PT. Laborindo, Jakarta.

The main instruments employed during the implementation of the research include those for the manufacture of cookies products (Oxone scales, Phillips mixer, Sharp electric oven, stainless steel basin, knives, mold, spoon, & fork) as well as analytical tools such as analytical balance, spectrophotometer, penetrometer, oven, furnace, desiccator, burette, Beaker glass, Erlenmeyer, Soxhlet, Easy Touch GCU type ET-301, and glucose test strip.

Research on product development of cookies made from functional cassava pulp flour was arranged in a Completely Randomized Design (CRD) with six levels of substitution of functional cassava pulp flour, namely, 0% (control), 10%, 20%, 30%, 40%, and 50%. Control was the treatment without the addition of composite flour (100% wheat flour). The data obtained are presented in the form of mean ± standard deviation. Each analysis was performed with three replications, except for testing the sensory characteristics (20 panelists) and the glycemic index value in vivo (10 volunteers). The data was then processed using ANOVA followed by the LSD test at a 5% significance level.

Table 1. Nutritional composition of functional cassava pulp flour

Component (%)	Composition
Water	9.41 ± 0.85
Ash	0.09 ± 0.03
Protein	4.24 ± 0.11
Carbohydrate	85.41 ± 1.18
Dietary Fibre	23.84 ± 1.41
Resistant Starch	7.31 ± 1.41
Fat	0.85 ± 0.22

Remarks: The mean is ± SD, n=3

Based on studies by Harmayani *et al*. (2011), making cookies from functional cassava pulp flour is done through procedure modification. This procedure begins with shaking butter with egg yolks at low speed for ± 3 min until a homogeneous cream is formed. Mix all dry ingredients such as wheat flour, cornstarch, fine salt, powdered sugar, vanilla, and baking powder into the dough; then stir until the dough is ready to be molded. Use a circular mold with a thickness of 0.5 cm to shape the dough. Bake the dough that has been formed in the oven at a temperature of ±130°C for 20 min. Testing the nutritional composition (AOAC, 1995), sensory characteristics, physical characteristics, and analysis of glycemic index values are all used to analyze the properties of baked products created from functional cassava pulp flour. Sensory characteristics were tested using the hedonic method, whereas physical characteristics were evaluated by texture testing using a penetrometer, nutritional composition, and in vivo glycemic index value analysis. In vivo glycemic index analysis was performed using 10 volunteers who had been selected with the condition that they were healthy and nondiabetic, having normal fasting blood sugar levels (70 - 120 mg/dL) and Body Mass Index value within the normal range of 18.5 - 25 kg/m^2. In vivo, glycemic index analysis was accomplished based on Ethical Exemption issued by Komite Etik Penelitian Kesehatan no. 310/KEPK-TJK/IX/2020 on September 16, 2020. The standard/reference food used is plain bread with a glycemic index value of 73 (Wolever, 1991). In vivo glycemic index analysis was performed using 10 volunteers who had been selected with the condition that they were healthy and nondiabetic, having normal fasting blood sugar levels (70 - 120 mg/dL) and Body Mass Index value within the normal range of 18.5 - 25 kg/m^2. In vivo, glycemic index analysis was accomplished based on Ethical Exemption issued by Komite Etik Penelitian Kesehatan no. 310/KEPK-TJK/IX/2020 on September 16, 2020. The standard/reference food used is plain bread with a glycemic index value of 73 (Wolever, 1991).

RESULTS AND DISCUSSION

Because functional cassava pulp has lower protein content than wheat flour, the decline in protein content is primarily due to this difference (Table 1, 4.24%). The carbohydrate content in cookies decreased with the increment in the functional cassava pulp flour formulation. Cookies with a 50% functional cassava pulp flour formulation had the lowest carbohydrate content of 63.02%. The carbohydrate content in the research cookies met the quality requirements of SNI 2973:2011 regarding the quality requirements of cookies, which was lower than 70%.

Nutritional composition

The results of testing the nutritional composition of cookie products on various functional cassava pulp flour formulations are presented in Table 2. The results of testing (Table 2) demonstrated that the functional cassava pulp flour formulation had a significant ($P<0.05$) effect on the content of dietary fiber, resistant starch, and fat. The development in the content of dietary fiber and resistant starch in cookie products was mainly connected to the content of dietary fiber and resistant starch in functional cassava pulp flour, which was 23.84% and 7.31%, respectively (Table 2). The presence of dietary fiber and resistant starch can affect blood glucose levels (Fernandes *et al*., 2005). In general, high content of dietary fiber and resistant starch leads to a low glycemic index value (Trinidad *et al*., 2010). The study's outcomes in Table 2 also illustrate that cookies with a 50% functional cassava pulp flour formulation have the lowest carbohydrate content of 63.02%. The carbohydrate content of the research cookies has met the quality requirements of SNI 2973:2011 regarding the quality requirements of cookies, which is lower than 70%.

Table 2. Nutritional composition of cookie products in various functional cassava pulp flour formulations

Component (%)	Control	10%	20%	30%	40%	50%
Water	2.65a	2.88a	2.98a	3.27a	3.23a	3.30a
Ash	0.90a	1.29a	1.25a	1.13a	1.22a	0.93a
Protein	4.18a	3.97a	3.97a	3.96a	3,85a	3.80a
Carbohydrate	63.1b	65.42ab	62.61b	67.36a	63.98ab	63.02b
Dietary Fiber	4.30f	6.26e	8.22d	10.17c	12.12b	14.08a
Resistant Starch	1.23f	1.84e	2.45d	3.05c	3.66b	4.27a
Fat	29.01a	26.35b	28.92ab	24.67c	27.69ab	28.97ab

Remarks:
The mean value followed by the same letter in the same row exhibits no significant difference in the 5% LSD test ($P\geq 0.05$)

Sensory analysis

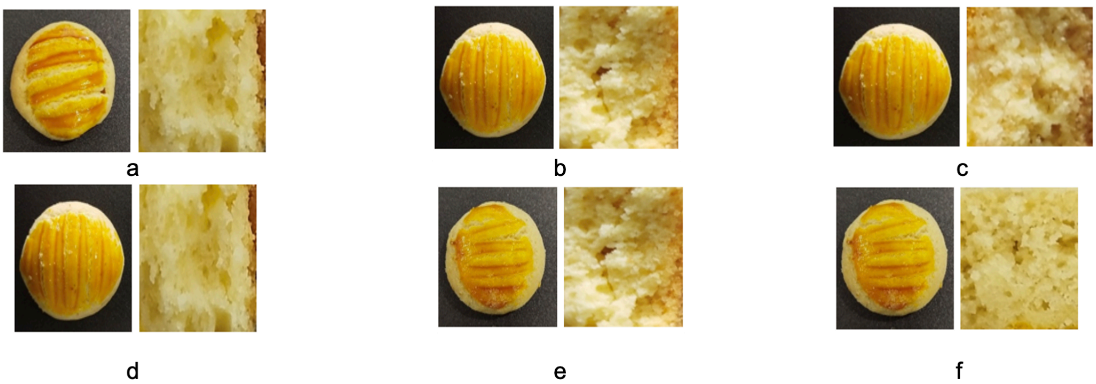
Sensory analysis of cookies products on various functional cassava pulp flour formulations is presented in Table 3 and cookies product is presented in Figure 1.

Sensory test results (Table 3) reveal that the higher the functional cassava pulp flour formulation, the lower the sensory test scores (aroma, taste, texture & overall appearance) of cookie products even though the average score is still within the score favored by consumers (>5). For the aroma score, compared to the control, the addition of 10% functional cassava pulp flour will elevate the aroma score (6,90 compared to 6,85). For the taste score, the addition of 20% functional cassava pulp flour will deliver cookies with the highest taste score compared to other treatments (6.95). For texture scores and overall appearance, the addition of 50% functional cassava pulp flour will yield cookies with the highest texture score (6,90) and the highest overall appearance (6,60). The higher texture score in the treatment with the addition of 50% functional cassava pulp flour is associated with the protein content and water content. A product's texture is influenced by its water content and protein content; the higher the protein content, the more water it absorbs, and the stronger the texture that results from it (Manonmani *et al*., 2014).

Table 3. Results of sensory test of cookies products on various Formulations of functional cassava pulp flour

No	Treatment	Aroma	Taste	Texture	Overall
1	Control	6.85	7.40	7.00	6.90
2	10%	6.90	6.80	5.55	6.40
3	20%	6.75	6.95	5.90	6.15
4	30%	6.10	6.40	6.15	5.95
5	40%	6.20	6.70	6.70	6.30
6	50%	5.95	6.25	6.90	6.60

Description of sensory test scores
1 = don't like it
2 = very dislike
3 = dislike
4 = rather don't like
5 = neutral
6 = rather like
7 = like
8 = very like
9 = really like it



Remarks: a. 0% functional cassava pulp flour, b. 10% functional cassava pulp flour, c. 20% functional cassava pulp flour
d. 30% functional cassava pulp flour, e. 40% functional cassava pulp flour, f. 50% functional cassava pulp flour

Fig. 1. Cookie products in various functional cassava pulp flour formulations

That is to say, the product's crispness, which is tied to the amount of resistant starch, is also connected with the treatment's higher texture score including 50% functional cassava pulp flour. An improvement in product crispness was associated with a rise in the content of resistant starch, as reported by Homayouni *et al*. (2014) and Ashwar *et al*. (2016). Based on the overall appearance score, the addition of 50% functional cassava pulp flour will produce cookies with the highest score compared to other treatments (6.60) which are strongly associated with higher texture scores (6,90).

Physical analysis

Table 4 displays the findings of the texture test conducted to assess the physical traits of cookies. The addition of functional cassava pulp flour up to 20% will reduce the texture value of the cookie product; however, the addition starting from 30% boosts the texture value of the resulting cookies. The texture value decrease in the functional cassava pulp flour formulation up to 20% was mainly related to changes in the composition of the ingredients, especially the water content and protein content which caused the product to be softer and lowered the hardness level (texture value). Increased dietary fiber and resistant starch are correlated with advancement in texture value starting with the inclusion of 30% functional cassava pulp flour. The higher the content of dietary fiber and resistant starch, the higher the texture value. A rise in the content of resistant starch tends to make the cookie product crispier but will boost the texture score. Due to the addition of resistant starch, the crispness and texture score developed; this had a direct correlation with crystallinity level (Haralampu, 2000; Alsaffar, 2011).

Table 4. The results of testing the texture of cookies on various functional cassava pulp flour formulations

Treatment	Texture (kg/50 mm^2)
Control (100% wheat flour)	0.55
10%	0.45
20%	0.48
30%	0.58
40%	0.62
50%	0.77

Glycemic index value analysis

The results of testing the area of the curve and the value of the glycemic index of cookies in various functional cassava pulp flour formulations are presented in Table 5. When the functional cassava pulp flour formulation becomes higher (Table 5), the cookies produced will have a lower glycemic index value. The decline in the glycemic index value in line with the escalation in the functional cassava pulp flour formulation is strongly linked with the content of dietary fiber and resistant starch.

Table 5. Curve area and glycemic index value of cookie products in various functional cassava pulp flour formulations

Treatment	Curve Area	IG Value
Reference food (white bread)	2,312.46	73.00
Control (100% wheat flour)	2,041.67	64.45
10%	1,666.01	52.59
20%	1,489.12	47.01
30%	1,405.74	44.38
40%	1,352.08	42.68
50%	1,276.33	40.29

The lower value of the glycemic index of cookies along with the increase in dietary fiber content is mainly due to a decrease in the glycemic response through the mechanism of matrix formation outside the starch granules so that it can inhibit carbohydrate digestion (Elleuch *et al*., 2011). The decrease in glycemic response is caused by 1) an increase in viscosity in the stomach so that it slows down the rate of emptying of the stomach and intestines and causes a decrease in the number of carbohydrates that can be digested (barriers to enzymes) and simple sugars that can be absorbed, 2) changes in hormone levels in the digestive tract, absorption of substances nutrition and insulin secretion, 3) increased insulin sensitivity which will stabilize blood glucose levels to protect complications due to diabetes (Alvarez & Sanchez, 2006).

Another factor that causes a decrease in the glycemic index content of cookies is the content of resistant starch. Resistant Starch (RS) is starch that cannot be digested by the small intestine so it will be passed on to the large intestine and fermented by bacteria that produce SCFA (Short Chain Fatty Acid), which will bind to organic molecules and water. Resistant starch can increase digesta viscosity so that it is absorbed more slowly (Ashraf *et al*., 2012), In addition, other advantages can reduce the glucose response, resulting in a low glycemic index (Muflihati, 2017). According to Mir *et al*. (2013), food products that have high levels of resistant starch can lower the glycemic index of these food products. The value of the glycemic index of cookies from research on 30% - 50% cassava pulp composite flour and 30% - 50% cassava pulp composite flour with high resistant starch is 40.27 - 52.59. According to Foster-Powel, *et al*. (2002), food categories according to the glycemic index range are low GI (<55), medium GI (55-70), and high GI (>70). So that the cookies of the research are included in the category of food with a low glycemic index.

CONCLUSIONS

Increasing the functional cassava pulp flour formulation to 50% in the manufacture of cookies will reduce the glycemic index value of the product to 40.29 (low glycemic index) with sensory characteristics that are still favored by the panelists.

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ETHICAL STATEMENT

This study was approved by the ethical committee “Komite Etik Penelitian Kesehatan”, approval number 310/KEPK-TJK/IX/2020 September 16, 2020.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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