BIO Web of Conferences **224**, 01010 (2026)
ISoFST 2025
https://doi.org/10.1051/bioconf/202622401010

Product Development of Low Glycemic Load Cookies in Order to Prevent Diabetes Mellitus

Yulia Astuti Tulastiati [1*], *Nurheni Sri* Palupi[1,2], and *Didah Nur* Faridah[1,2]

[1]*Department of Food and Science and Technology, Faculty of Agricultural Engineering and Technology, IPB University (Bogor Agricultural University), Bogor 16680, Indonesia*

[2]*Southeast Asian Food and Agricultural Science and Technology (SEAFAST) Centre, IPB University (Bogor Agricultural University), Bogor 16680, Indonesia*

Abstract. Developing a fast-paced modern lifestyle has changed people's food consumption patterns and physical activities. It has the potential to trigger non-communicable diseases such as diabetes mellitus. One of the attempts to deal with it is through lifestyle modification. This study aims to develop healthy cookies made from red bean flour (GI 26), taro flour (GI 60), and corn flour (GI 36), which contain a low GI. Cookie GI testing was conducted using the ISO 26642:2010 method. Flour and cookies were formulated using red bean flour, sweet corn, and silk taro with three different ratios, F1 (50:25:25), F2 (25:50:25), and F3 (25:25:50), and were analyzed for physical chemical. Sensory analysis of cookies was conducted using a hedonic test, and the highest sensory acceptance results were then measured in terms of glycemic index and glycemic load. The results showed that F1 cookies were the most preferred (hedonic score of 3.6), with a protein content of 15.15±0.02%, resistant starch of 17.07±0.01%, and starch digestibility of 55,29±0.19%. F1 cookies are classified as low GI (52) and GL (7.9), so they have the potential as a snack for people with type 2 diabetes and for the prevention of the disease.

1 Introduction

The development of modern lifestyles has brought significant changes to people's lifestyles. It is marked by increased consumption of low fibre fast food and packaged sweetened beverages, also known as Sugar-Sweetened Beverages (SSBs) and decreased physical activity. This change is thought to be a trigger for the increase in non-communicable diseases (NCDs), one of which is diabetes mellitus (DM) (Astutisari et al., 2022). DM is a serious disease that occurs when the pancreas does not produce enough insulin or when the insulin produced cannot be used effectively, resulting in high blood glucose levels (WHO, 2016). DM has become a global health issue with a steadily increasing prevalence. According to the International Diabetes Federation (IDF, 2021), in 2021, 537 million people were living with diabetes worldwide, which is projected to reach 783 million by 2045. Indonesia ranked fifth with 19.5 million people with diabetes in 2021, a figure projected to rise to 28.6 million by 2045.

Lifestyle modification serves as a cornerstone in the management of diabetes mellitus, with the primary goal of enhancing glycemic control and minimizing the risk of long-term complications. One key component of this approach is the regulation of nutritional intake, particularly the selection of carbohydrates based on their glycemic index (GI), considering both their quantity and quality. High-GI foods are known to cause rapid and significant increases in blood glucose levels. When consumed consistently by individuals with diabetes, these foods may contribute to insulin resistance and elevate the risk of developing diabetes-related complications (Mayawati dan Isnaeni, 2017). Besides GI, glycemic load (GL) is important because it is calculated by multiplying the GI of a food by the number of grams of carbohydrates consumed daily and then dividing the result by 100 (Ningrum, 2011).

Red beans, corn, and taro are local foods that have great potential as alternatives to wheat flour in diversifying food products, including in the process of making cookies. Red beans have high protein content (25.33%), dietary fiber (25.49%), and a low GI (26) (Afandi et al., 2021). Corn, especially sweet corn, has a GI of 36 (Daniels Evan, 2023) and a carbohydrate content of 80.46%, and has gone through a gelatinization process that increases shelf life and ease of digestion (Marta dan Tensiska, 2016). Taro, with a GI of 60 (Endyra, 2024), is a local carbohydrate source that is rich in starch (70-80%), although it has weaknesses such as an unpleasant taste and sticky texture due to its high amylopectin content (Purnamasari dan Putri, 2015).

The development of cookie products using mixed flour from red beans, corn, and taro offers several advantages, such as higher fibre, protein, and other

* Corresponding author: hnpalupi@apps.ipb.ac.id

 https://doi.org/10.1051/bioconf/202622401010

nutrient content, as well as a lower GI compared to wheat flour (GI 70) (Adelina et al., 2025). The combination of these three ingredients facilitates food diversification and produces snack products that meet the requirements of a contemporary lifestyle. By utilizing these local ingredients, it is hoped that they can contribute to the management of DM and improve the quality of life of the community. This study aims to: (1) Determine the selected formulation based on characterization of physical, chemical, and sensory properties; (2) Analyze the effect of formulation differences on nutritional value; (3) Test the glycemic index and glycemic load values of the selected cookie formulation.

2 Materials and methods

2.1. Material preparation

The raw materials used in this study are dried kidney beans obtained from vegetable traders in Babakan Raya, Bogor, silk taro obtained from CIFOR market, Bogor, West Java, Indonesia, an exotic sweet corn obtained from vegetable traders at Pasar Induk Kemang, Bogor. Additional ingredients used to make cookie products are eggs, margarine, full cream milk, cheese spread, baking soda, and water. The tools used in making flour, cookies, and analysis are an drum dryer, a fluidized bed dryer, an oven, a Kjeldahl distillation unit, and a Soxhlet extraction.

2.2. Material preparation

This research consists of three stages, namely the making and characterizing the physical-chemical properties of flour, the making and characterizing the physical-chemical and sensory properties of cookies, and the calculation of the glycemic load of cookies.

2.3. Sample preparation

First, the process of making red bean flour by involves drying with a fluidized bed dryer (FBD). The red beans are soaked for 2 hours at a room temperature, then steamed with a steam blancher at 100°C for 30 minutes and then peeled. Soaking and peeling the red bean skin aims to reduce the antinutrient content, namely the levels of phytic acid and tannins that can hinder mineral absorption, the soaking process also aims to help reduce steaming time because the water absorbed by the red beans makes the texture of the beans softer and easier to cook (Huma et al., 2008). The peeled red beans are stored in the freezer overnight and dried with FBD at a temperature of 40-50°C for 2 hours. After that, it is ground using a miller machine and sieved with a 60-mesh sieve.

The production of sweet corn flour and silky taro flour was carried out using a drum dryer. Sweet corn is skinned, washed clean and kernels are removed. Silk taro is peeled, cut into cubes measuring 1x1 cm, then soaked in salt water (5% NaCl in 1 L of water) for 30 minutes, aiming to remove the sap and reduce the calcium oxalate content in taro flour by 72.37% (Mayasari, 2010). Taro and sweet corn are rinsed with running water and steamed for 15 minutes with a steam blancher at a temperature of 100 °C. Each ingredient (taro and corn) is put into a double-drum dryer. The settings for the drum dryer are a drum surface temperature of 110 °C, a speed of 3 rpm, a gap between drums of 0.02 cm and a steam pressure of 4.5 kg/cm^2. After that, all the ingredients are refined using a miller machine and sieved with a 60 sieve.

Secondly, the cookie preparation process commenced with the weighing of ingredients by specified formulations, using the following ratios of red bean flour:corn:taro —F1(50:25:25), F2 (25:50:25), and F3 (25:25:50). The additional ingredients incorporated into the formulation included margarine (40%), eggs (20%), full cream milk (4%), spreadable cheese (4%), baking soda (1%), and water (10%). Initially, margarine and eggs were mixed using an electric mixer for one minute. Subsequently, the flour mixture, full cream milk, spreadable cheese, baking soda, and water were added and mixed until homogeneous. The resulting dough was then molded, arranged on a baking tray, and baked in an oven at approximately 130°C for about 23 minutes.

2.4. Analytical methods

The analysis of flour and cookies included proximate composition, dietary fiber, resistant starch, and starch digestibility. Moisture, ash, and fat content were determined according to AOAC 920.39 (AOAC 2012), protein content by AOAC 960.52 (AOAC 2012), carbohydrate content by AOAC 986.25 (AOAC, 2012), dietary fiber by AOAC 985.29 (AOAC, 2003), in vitro resistant starch (Goñi *et al*. 1996), and in vitro starch digestibility (Anderson *et al*. 2002). Color was analyzed using a chromameter CR 300-Minolta, and water activity was measured with an Aqualab 4TE.

2.5. Sensory analysis – Hedonic scale

The hedonic rating test, referring to SNI 01-2346-2006 (BSN, 2006), was conducted to evaluate aroma, taste, texture, color, and overall acceptability attributes to determine panelists' preference levels for the cookie product. The evaluation was carried out by 50 untrained panelists consisting of students and staff from the Department of Food Science and Technology, IPB University. The sensory attributes were assessed using a 5-point hedonic scale, ranging from 1 (strongly dislike) to 5 (strongly like).

2.6. In vivo glycemic index

The glycemic index (GI) testing referred to ISO 26642 (ISO, 2010) and involved 16 research subjects. Glucose was used as the reference food and cookies as the test food, both consumed in portions equivalent to 50 g or 25 g of available carbohydrates. Subjects fasted completely (except for water consumption) for 10–12 hours before testing, which began between 08:00 and 09:00 AM. Blood samples were taken at minute 0 (before consuming the reference/test food) and at 15, 30, 45, 60, 90, and 120 minutes after consumption of the reference/test food. The glucose reference test was repeated twice, while the test food was evaluated once. The glycemic response was expressed as the Incremental Area Under the Curve (iAUC), calculated geometrically by ignoring the area under the baseline glucose level. The mean, standard deviation (SD), and coefficient of variation (CV = 100 × SD/mean) of the iAUC were calculated for the two glucose tests and the test food. The GI value of the test food was expressed as the average GI of all subjects. The GI and glycemic load (GL) of each test food for each subject were calculated using Equations 1 and 2 below:

$$\mathrm{GI} = \frac{\text{mean iAUCtest food}}{\text{mean iAUC glucose}} \times 100 \qquad (1)$$

$$\mathrm{GL} = \frac{\text{GI x available carbohydrate per serving}}{100} \qquad (2)$$

2.7. Data analysis

This research employed a Completely Randomized Design (CRD) with a single factor, namely the difference in formulation of red bean, corn, and taro flour, with two replications for each treatment. The data were presented as mean ± standard deviation and analyzed using Analysis of Variance (ANOVA) to determine significant differences among treatments. When significant differences were observed, the analysis was further continued with Duncan's Multiple Range Test (DMRT) using IBM SPSS software at a 95% confidence level.

3 Result and Discussion

3.1. Characterization of the Chemical Properties of Formulated Flour and Cookies

Flour serves as a primary raw material in cookie production and plays a vital role in determining the final texture of the product, alongside the contribution of fats. The characterization of the chemical properties of the flour formulations and cookies in this study includes proximate analysis, dietary fiber content, resistant starch, and starch digestibility, as presented in Table 1. Analysis of variance (ANOVA) results indicated statistically significant differences (α = 5%) among the flour formulations and cookies labeled F1, F2, and F3 across various tested parameters. The inclusion of 50% red bean flour in the F1 formulation had a significant impact on the moisture, protein, and dietary fiber content of the flour. The F1 formulation exhibited the highest moisture content on a wet basis (11.40±0.01%), followed by F2 (9.09±0.01%) and F3 (8.01±0.01%). The increase in moisture content was proportional to the increasing proportion of red bean flour. This phenomenon is attributed to the red bean flour being processed using Fluidized Bed Drying (FBD) at a relatively low drying temperature of 50°C, resulting in a high initial moisture content (24.38%). In contrast, corn and taro flours were processed using drum drying, yielding lower moisture contents of 7.28% and 6.68%, respectively.

Drying temperature of raw flour materials significantly influences final moisture content; higher temperatures accelerate water evaporation (Purwanti et al,. (2017). Moisture content, in turn, affects the stability, shelf life, and overall quality of flour. The protein content in the F1 flour formulation was also the highest, measured at 17.45±0.04% (dry basis), compared to F2 (14.38±0.02%) and F3 (12.60±0.02%). This is primarily due to the inherently high protein content of red bean flour (22.85%), which is considerably greater than that of corn flour (9.2%) (Kasih, 2019)and taro flour (7.16%) (Cahyaningtyas et al., 2024). The addition of red bean flour not only significantly increased protein levels but also enriched the formulation with a valuable source of plant-based protein.

Total dietary fiber content showed a similar upward trend in correlation with increased red bean flour addition, with values of 20.54% (F1), 19.03% (F2), and 18.81% (F3) on a dry basis. These findings are consistent with Wahjuningsih et al. (2018), who reported that incorporating red bean flour into cereals made from red rice flour elevated the dietary fiber content. Red bean flour contains 14.32% total dietary fiber, composed of 8.82% insoluble fiber and 5.50% soluble fiber, thereby supporting the fiber-enhancing effect of red bean flour inclusion.

The addition of more corn flour to formulation F2 (50%) significantly impacted the fat content, which was 4.91±0.02%. In comparison, formulations F1 and F3 showed fat content of 3.26±0.02% and 3.36±0.02%, respectively. Corn flour possesses a higher fat content than red bean and taro flour, approximately 3.9 g/100 g (Prasetyo et al., 2014).

In contrast, the F3 formulation, which incorporated 50% taro flour, demonstrated the highest starch digestibility (85.92±0.20%, dry basis). This may be attributed to taro's starch composition, which includes 20–25% amylose and 75–80% amylopectin, as well as its very fine starch granule size (1–5 μm). These characteristics enhance the digestibility of taro starch by facilitating enzymatic hydrolysis via α-amylase, which breaks α-1.4-glycosidic bonds in starch molecules into simple sugars (Hasnelly et al., 2020; Arifsyah et al., 2022).

The formulated flours that have been characterized were further processed into cookies. The nutritional composition of food products is significantly influenced by the processing steps—before, during, and after production. Thermal processes, such as baking, can lead to changes or reductions in nutrient content.

Based on Table 1, the moisture content (wet basis) of the cookies was still relatively high: F1 cookies had 10.78±0.01%, F2 had 6.12±0.00%, and F3 had 4.63±0.05%. The moisture content of F1 and F2 cookies did not meet the Indonesian National Standard (SNI) 2973-2011 for biscuits (cookies), which sets a maximum moisture content of 5% (BSN, 2011). Several factors can affect moisture content in cookies, such as baking temperature and time, the initial moisture content of the flour, and the use of additional ingredients like margarine, eggs, and milk. Baking time and temperature play important roles in reducing cookie moisture. According to research by Polnaya dan Breemer (2016) and Yashinta et al. (2021), baking at high temperatures (150–180°C) or for a longer duration increases the evaporation rate of water from the dough, resulting in cookies with lower moisture content and a drier, more stable texture. The flours used had moisture contents ranging from 8.01% to 11.40% (wb), which also affected the final moisture level of the cookies (Rosania et al., 2023). Red bean flour dried using a fluidized bed dryer (FBD) still had a high moisture content, suggesting that the drying time needs to be extended to produce low-moisture flour. Margarine used in the formulation (40%) contains 80% fat and the rest is water (Rosida et al., 2020). The fat in margarine acts as a water-in-oil (w/o) emulsion, which can inhibit water evaporation during baking, thus increasing the moisture content of the cookies.

Adding of red bean flour to the cookies influenced the content of protein, dietary fiber, and resistant starch (RS) on a dry basis. F1 cookies had the highest values: protein at 15.15±0.02%, total dietary fiber at 14.82±0.55%, and resistant starch at 17.07±0.01%. There was a decrease in dietary fiber content from the flour to the final cookie products (F1, F2, and F3), as shown in Table 1. This reduction was due to adding ingredients like sugar, fat, eggs, or emulsifiers, diluting the flour proportion in the final product. As a result, the fiber content per gram of cookie was lower than that in the raw flour.

Changes in resistant starch content from flour to cookies showed an increase in F1 and F3, but decreased in F2. Processing plays a key role in RS formation by modifying starch gelatinization and retrogradation. During baking, starch undergoes gelatinization due to heat. After baking, as the cookies cool, the gelatinized starch undergoes retrogradation, forming crystalline structures. This transformation increases RS content in the food. RS is one of dietary fiber components, so an increase in RS also contributes to a higher total dietary fiber content in the final product (Rosephin, 2010).

Starch digestibility in the cookies was lower than in the original flour, as seen in F2 and F3 (Table 1). This can be attributed to several factors, including dietary fiber content, RS, and the presence of antinutritional compounds such as tannins Prasetyo 2008). According to Fitriani et al. (2020), several factors may reduce starch (carbohydrate) digestibility, including high processing temperatures, interactions between starch and non-starch components, and the presence of resistant starch. In addition to baking temperature, the fat content in cookies can also affect starch digestibility. During heating, amylose can form single-helix inclusion complexes with lipids (starch–lipid complexes), reducing enzymatic hydrolysis by limiting enzyme access to the starch. In contrast, interactions between amylopectin and lipids are generally considered much weaker (Chao et al., 2024). Amylase enzymes that break down starch into glucose can be inhibited by fat. This results in less starch being hydrolyzed and absorbed by the body, leading to lower blood glucose levels.

Table 1. Chemical characteristics of formulated flour and cookies

Parameter	**Product**					
	F1 (50B+25C+25T)		**F2 (25B+50C+25T)**		**F3 (25B+25C+50T)**	
	F	**Cookies**	**F**	**Cookies**	**F**	**Cookies**
Moisture (%) (wb)	11.40±0.01^{c}	10.78±0.01^{c}	9.09±0.01^{b}	6.12±0.00^{b}	8.01±0.01^{a}	4.63±0.05^{a}
Ash (%) (db)	2.87±0.03^{a}	3.46±0.02^{b}	3.04±0.03^{b}	3.39±0.02^{a}	3.04±0.01^{b}	3.49±0.00^{b}
Fat (%) (db)	3.26±0.02^{a}	28.47±0.01^{a}	4.91±0.02^{c}	29.80±0.01^{c}	3.36±0.02^{b}	29.34±0.02^{b}
Protein (%) (db)	17.45±0.04^{c}	15.15±0.02^{c}	14.38±0.02^{b}	12.23±0.02^{b}	12.60±0.02^{a}	11.81±0.05^{a}
Carbohydrate (%) (db)	76.42±0.01^{a}	52.91±0.05^{a}	77.66±0.03^{b}	54.58±0.02^{b}	80.99±0.01^{c}	55,36±0.00^{c}
Energy (kkal)	323	419	336	462	329	490
Dietary fiber (%) (db)	20.54	14.82±0.55^{b}	19.03	11.38±0.48^{a}	18.81	10.72±0.37^{a}
Resistant starch (%) (db)	11.34±0.05^{a}	17.07±0.01^{c}	11.43±0.03^{a}	10.96±0.02^{a}	11.53±0.00^{b}	12.79±0.14^{b}
starch digestibility (%) (db)	46.98±0.11^{a}	55.29±0.19^{b}	66.53±2.48^{b}	51.53±0.10^{a}	85.92±0.20^{c}	70.04±0.04^{c}

The data is shown as the mean ± standard deviation (n=2). Significant differences according to DNMRT (p<0.05) are shown superscript letters in the same column. Dry basis (db) and wet basis (wb). F: flour; B: red bean; C: corn; T: taro.

3.2. Characterization of the Physical Properties of Composite Flours and Cookies

Cookie color measurement was conducted objectively using a Minolta CR-400 Chromameter, which provides three color parameters in the CIE Lab* system. The characteristics data of the flour and cookie products, including color parameters and water activity, are presented in Table 2. A significant color change occurred during the processing from flour into cookies. The original flour color was bright, with L values ranging from 77.93 to 79.59, but drastically decreased to between 45.85 and 49.71 in the cookie products. This reduction in lightness indicates the formation of brown color in the cookies as a result of the baking process.

Table 2. Physic characteristics of formulated flour and cookies

Parameter	Treatment					
	F1 (50B+25C+25T)		F2 (25B+50C+25T)		F3 (25B+25C+50T)	
	F	Cookies	F	Cookies	F	Cookies
Color						
L*	78.84±0.54^{b}	47.17±0.33^{b}	77.93±0.29^{a}	45.85±0.27^{a}	75.71±0.21^{c}	49.71±0.01^{c}
a*	2.70±0.03^{b}	10.46±0.08^{b}	2.92±0.08^{c}	10.21±0.04^{a}	6.17±0.05^{a}	11.69±0.06^{c}
b*	26.99±0.09^{b}	33.55±0.09^{b}	32.86±0.65^{c}	31.30±0.06^{a}	25.68±0.19^{b}	36.62±0.10^{c}
Water activity (a_w)	0.64±0.00^{c}	0.56±0.01^{a}	0.55±0.00^{b}	0.67±0.02^{b}	0.52±0.00^{a}	0.59±0.01^{a}

The data is shown as the mean ± standard deviation (n=2). Significant differences according to DNMRT ($p<0.05$) are shown superscript letters in the same column. F: flour; B: red bean; C: corn; T: taro.

The formation of the brown colour in cookies is primarily caused by the Maillard reaction, a non-enzymatic reaction between reducing sugars and compounds containing primary or secondary amine groups, such as proteins, amino acids, and peptides. At high baking temperatures, reducing sugars react with amine groups to form intermediate compounds like glucosamine, which then undergo further reactions forming dark-coloured compounds known as melanoidins. These compounds contribute to the characteristic brown colour of baked goods (Cicilia et al., 2021).

In addition to colour, another important physical characteristic of cookie products is water activity (aw), which indicates the amount of free water available to support microbial growth. The aw values of the cookies in this study ranged from 0.56 to 0.67, with cookie F2 showing the highest aw value. In general, an aw value of <0.70 is still considered safe against the growth of pathogenic microbes and extends the product's shelf life.

The increase in a_w value in cookies, particularly in formula F2, may be influenced by several factors, including the type of packaging used, and additional ingredients such as milk and corn flour. Corn flour contains a relatively high amount of sugar and is hygroscopic, meaning it tends to absorb moisture from the environment into the product. This can increase the amount of free water in the product, as reflected by the higher a_w value.

3.3. Cookies Hedonic Test

A hedonic test was conducted on cookies made from a combination of red bean flour, corn flour, and taro flour, with the respective proportions F1 (50:25:25), F2 (25:50:25), and F3 (25:25:50), as presented in Figure 1. The evaluation was carried out by 50 untrained panelists using a hedonic rating method on six sensory attributes: color, aroma, taste, texture, aftertaste, and overall preference, using a 1–5 scale (1 = strongly dislike, 2 = dislike, 3 = neutral, 4 = like, and 5 = strongly like). Figure 2 presents the hedonic test data with the average preference scores of the panelists for the cookies. This study received ethical approval from the Ethics Committee for Research of IPB University under the number: 1444/IT3.KEPMSM-IPB/SK/2024. This approval ensures that the study adheres to ethical principles, including respect for the rights and well-being of research subjects, which will be used in the hedonic and glycemic index tests.

Figure 1. Cookies from a mixture of red kidney bean, corn, and taro flour: (a) Cookie F1 (b) Cookie F2 (c) Cookie F3

Colour is a primary element in visual perception and serves as the first indicator of consumer acceptance of a product. Based on the hedonic test results, formulation F1 obtained the highest average score for color (3.7), indicating a higher preference compared to formulations F2 and F3. Aroma is also an important factor in the perception of quality and appeal of food products. For the aroma parameter, there were no significant differences among the three formulations at a significance level of α = 5%. The characteristic aroma of cookies is mainly produced through the Maillard reaction during the baking process, which becomes more intense with increased protein content in the raw materials. In addition, aroma is also influenced by the use of ingredients such as butter, milk, eggs, cheese, and flour (Ulmanun et al., 2024).

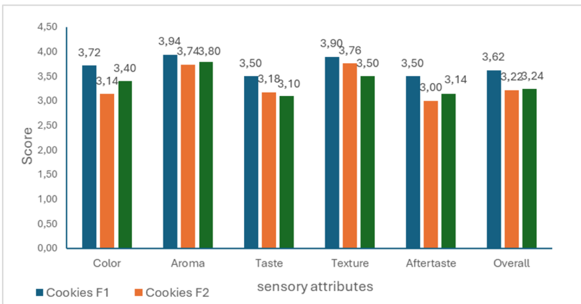

Figure 2. Hedonic test with the average preference score of panelists

Taste is the main determining factor in consumers' final decision regarding the acceptance of a food product. Even if attributes such as color, aroma, and texture are favorable, a product can still be rejected if the taste does not align with consumer preferences. The results of the

 https://doi.org/10.1051/bioconf/202622401010

hedonic test for the taste attribute showed no significant differences among the three formulations at a significance level of α = 5%.

Texture plays an important role in the sensory perception of cookies as it relates to the chewing experience and consumption comfort. The hedonic test for texture also showed no significant differences among the three formulations. The average panelist preference scores ranged from 3.5 to 3.9, which falls within the neutral response range. Visually, F1 cookies were rated as having the crunchiest texture, easy to break and melt in the mouth, while F2 was moister, and F3 was crispy and crumbly.

Aftertaste is the impression perceived or felt after consuming a food. Based on the hedonic preference test results, there was a significant effect on the aftertaste parameter in F1 cookies (3.50). The final parameter is the overall rating, which is a composite parameter encompassing color, aroma, taste, texture, and aftertaste. The highest overall score was recorded for F1 cookies, with a score of 3.6.

3.4. The Selection of The Preferred Product

The preferred product selection aims to determine the most favored ratio of red bean, corn, and taro flours in the cookies. Based on the overall hedonic sensory test results, the cookie with the highest preference score was made with formula F1 flour (3.6). Overall, respondents' preference for F1 cookies was significantly different from that for F2 and F3 cookies at the 95% confidence level.

3.5. Evaluation of the Glycemic Load of Cookies

The glycemic index (GI) is a physiological indicator used to describe how quickly the carbohydrates in a food raise blood glucose level after consumption. Foods with a high GI cause a rapid spike in blood glucose, while low-GI foods increase blood glucose levels more slowly and gradually (Wari et al., 2023). In addition to GI, glycemic load (GL) is also important for assessing the overall blood glucose response, as it considers both the amount of carbohydrates consumed in one serving and the glycemic index. Therefore, GL provides a more comprehensive picture than GI alone in evaluating the glycemic impact of a food (Istiqomah dan Rustanti, 2015).

A proximate and dietary fiber analysis was conducted to determine the quantity of F1 cookies needed for test subjects to consume 25 grams of available carbohydrates, per BPOM RI (2011) guidelines, before the GI test. In the first stage, the respondents consumed 25 grams of pure glucose (reference food) twice on separate days. In the second stage, at a different time, the respondents consumed 65.58 grams of F1 cookies, equivalent to 25 grams of available carbohydrates.

Figure 3 below shows the glycemic response of the respondents, measured at seven-time intervals: 0, 15, 30, 45, 60, 90, and 120 minutes after consuming the standard food (glucose) and the test food (cookies). Fasting blood glucose level (baseline) was determined at minute 0. After consuming either glucose or cookies, blood glucose levels increased from baseline starting at minute 15, peaking at minute 30, and then gradually declined until minute 120. The peak blood glucose level after consuming pure glucose reached 150 mg/dL, whereas after consuming the cookies it reached 125 mg/dL. This pattern shows that pure glucose is absorbed faster than the complex carbohydrates in the cookies. This result is consistent with findings from Eliana et al. (2018) and Gemala Anjani et al. (2023), who reported that glycemic response begins at minute 15, peaks at minute 30, and then gradually declines as a homeostatic mechanism of the body to balance blood glucose levels.

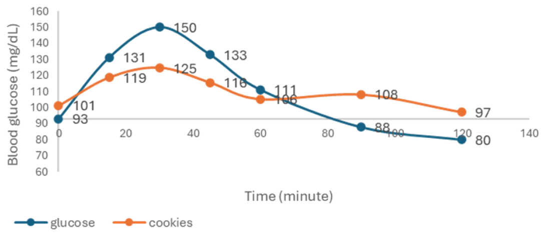

Figure 3. Blood glucose response of respondents to test foods

The glycemic index (GI) value of F1 cookies, formulated with red bean flour (50%), corn (25%), and taro (25%), is 52 ± 19. This value falls into the low category according to BPOM Regulation No. 1 of 2022, which classifies GI as follows: low (≤55), medium (56–69), and high (≥70).

Furthermore, this result meets the validity criteria for GI testing based on Brouns et al. (2005), which require a standard error of the mean (SEM) of ≤20% of the average GI value (in this study, SEM = 18.82%), and a coefficient of variation (CV) for the reference food of ≤30% (in this study, CV = 12.50%) (ISO 26642:2010).

According to BPOM Regulation No. 26 of 2021, the serving size for cookies ranges from 15 to 50 grams. In this study, one serving was set at 20 grams. Based on 25g the available carbohydrate content, one serving of the cookie contains 15.25 grams of carbohydrates, resulting in a Glycemic Load (GL) of 7,9. This value also falls into the low category, according to BPOM No. 1 of 2022, which classifies GL as: low (≤10), medium (11–19), and high (≥20).

Thus, cookies made with a combination of 50% precooked red bean flour, 25% corn, and 25% taro can be considered a low-GI snack option, suitable for maintaining or preventing spikes in blood glucose levels

4. Conclusion

Cookies made from red bean, corn, and taro flour—comprising three different formulations—showed significant differences in their physicochemical properties. The selected formula (F1), comprising red beans, corn, and taro in a ratio of 50:25:25, contains significant components such as dietary fiber and resistant starch, which contribute to the regulation of glycemic responses. Furthermore, F1 cookies fall within the category of foods classified as having a low glycemic index and glycemic load, according to PerBPOM No. 1 of 2022. Therefore, these cookies have the potential to serve as an alternative snack for maintaining or preventing blood glucose spikes in individuals with type 2 diabetes mellitus, and as a functional food for the prevention of type 2 diabetes

5. Acknowledgement

This research was funded by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia (Kemendikbudristek) under the 2024 Main Contract No. 027/E5/PG.02.00.PL/2024, with additional support from the Food Science and Technology Department Laboratory at the Faculty of Agricultural Technology, IPB University.

Journal articles

1. [WHO] World Health Organization. 2016. Global Report on Diabetes. Volume ke-978
2. [BSN] Badan Standar Nasional. 1992. SNI 01-2891-1992. Cara Uji Makanan dan Minuman. Badan Standarisasi Nasional.
3. [AOAC] Association of Official Analytical Chemists**.** 2000. Official Methods of Analysis of AOAC International. 17th ed. Gaithersburg, MD: AOAC International. Method 960.52: Microchemical determination of nitrogen
4. [AOAC] Association of Official Analytical Chemists**.** 2012. Official Methods of Analysis of AOAC International. 19th ed. Gaithersburg, MD: AOAC International. Method 986.25: Carbohydrates.
5. [AOAC] Association of Official Analytical Chemist**.** 1990. Official Methods of Analysis of AOAC International. 15th ed. Arlington, VA: AOAC International. Method 985.29: Total dietary fiber in foods.
6. [BSN] Badan Standarisasi Nasional. 2006. SNI 01 2346-2006. Petunjuk Pengujian Organoleptik Atau Sensori. Badan Standarisasi Nasional. Jakarta
7. [BSN] Badan Standar Nasional. 2011. Biskuit. SNI 01-2973-2011. BSN, Jakarta
8. [BPOM] Badan Pengawasan Obat dan Makanan. 2011. Peraturan Kepala Badan Pengawas Obat dan Makanan Republik Indonesia Nomor HK.03.1.23.11.11.09909 Tahun 2011 Tentang Pengawasan Klaim dalam Label Iklan Pangan Olahan. BPOM RI.:1–46
9. [ISO] International Organization for Standardization. 2010. ISO 26642:2010 Food products - Determination of the glycaemic index (GI) and recommendation for food classification. Geneva: ISO
10. [IDF] International Diabetes Federation. 2021. IDF Diabetes Atlas 10th edition. IDF 2021. http://diabetesatlas.org (diakses pada tanggal 10 Januari 2025)
11. Astutisari IDAEC, AAA Yuliati Darmini AYD, Ida Ayu Putri Wulandari IAPW. 2022. Hubungan pola makan dan aktivitas fisik dengan kadar gula darah pada pasien diabetes melitus tipe 2 di puskesmas Manggis I. Jurnal Risiko Kesehatatan Nasional 6(2):79–87.doi:10.37294/jrkn.v6i2.350
12. Afandi FA, Wijaya CH, Faridah DN, Suyatma NE, Jayanegara A. 2021. Evaluation of various starchy foods: A systematic review and meta-analysis on chemical properties affecting the glycemic index values based on in vitro and in vivo experiments. Foods, 10(2). https://doi.org/10.3390/foods10020364.
13. Adelina N., Aziz L, Fauziyah A, Mevera K, Salmatyanti N. 2025. Karakteristik kimia, sifat fungsional, dan prediksi indeks glikemik tepung komposit berbasis hanjeli (coix lacryma-jobi) termodifikasi. Jurnal Al-Azhar Indonesia. *S*eri sains dan teknologi. 10(1):97–109
14. Arifsyah, J., D. P. Dewi, dan S. Wahyuningsih. 2022. Pengaruh substitusi tepung talas (colocasia esculenta) dan tepung beras merah (oryza nivara) terhadap kadar proksimat dan kadar zat besi pada mochi. Jurnal Ilmu Gizi Indonesia. 5 (2). 141-150. Yogyakarta: Universitas Respati.
15. Cahyaningtyas IGAP., Putra INK, Wiadnyani AAIS. 2024. Pengaruh perbandingan tepung talas beneng (xanthosoma undipesh k . koch) dan tepung kacang hijau (vigna radiate) terhadap karakteristik kukis bebas gluten. Jurnal Ilmu dan Teknolologi Pangan. 13 (3)(1):454–472
16. Prasetyo, R. 2008. Evaluasi mutu gizi dan indeks glikemik produk olahan hotong (Setaria etalica). Skripsi. Fakultas Teknologi Pertanian Institut Pertanian Bogor. 80 hlm
17. Fitriani L, Sadimantara MS. 2020. Kajian pengembangan produk cookies berbasis tepung ubi jalar ungu (Ipomoea batatas L) fermentasi dengan substitusi bubuk kakao (Theobroma cacao) untuk menghasilkan produk cookies. Jurnal Sains dan Teknologi Pangan. 5(2):2772–2785
18. Chao C, Liang S, Zhang Z, Gidley MJ, Liu Y, Wang S. 2024. New Insight into the Effects of Endogenous Protein and Lipids on the Enzymatic Digestion of Starch in Sorghum Flour. Foods. 13(5):1–15.doi:10.3390/foods13050663
19. Cicilia S, Basuki E, Alamsyah A, Yasa IWS, Dwikasari LG, Suari R. 2021. Sifat fisik dan daya terima cookies dari tepung biji nangka dimodifikasi. Jurnal Proses Saintek. 3:9–10.
20. Istiqomah Annisa; Ninik Rustanti. 2015. Indeks glikemik, beban glikemik, kadar protein, serat dan tingkat kesukaan kue kering tepung garut dengan substitusi tepung kacang merah. Jurnal Nutrition Collage. 4:428–434.
21. Eliana F, Handoko IS, Ambarwati FD, Setiawati A. 2018. Profil respons glukosa darah dan tingkat rasa kenyang setelah pemberian diabetasol dibandingkan makanan padat gizi terkontrol pada pasien diabetes melitus tipe 2. Jurnal Ners dan Kebidanan Indonesia. 1(3):71.
22. Gemala Anjani, Dewi Marfu’ah Kurniawati, Ahmad Syauqy, Rachma Purwanti, Diana Nur

Afifah, Tasya Safira Meliasari, Nur Faizah. 2023. Potential of local fruits (kersen (muntingia calabura), kawista (limonia acidissima) and trembesi (samanea saman) as sweetener with low glycemic index and glycemic load. Media Gizi Indonesia. 18(1):82–93.doi:10.20473/mgi.v18i1.82-93

23. Hasnelly, Nurminabari, Siti, I. and Meiliawati, Audina, D. 2020. Pengaruh perbandingan tepung talas bogor (colocasia esculenta l. schott) dengan tepung ubi jalar oranye (ipomea batatas l) dan waktu fermentasi terhadap karakteristik crackers sayuran. Pasundan Food Technology Journal, 7(2)
24. Huma N, Anjum FM, Sehar S, Issa Khan M, Hussain S. 2008. Effect of soaking and cooking on nutritional quality and safety of legumes. Nutr. Food Sci. 38(6):570–577.doi:10.1108/00346650810920187
25. Kasih DRR. 2019. pengaruh proporsi tepung jagung dan tepung kacang merah terhadap sifat organoleptik serta kandungan gizi brownies kukus. e-Jurnal Tata Boga. 8(2):371–379
26. Mayawati, H., & Isnaeni, F. N. (2017). Hubungan asupan makanan indeks glikemik tinggi dan aktivitas fisik dengan kadar glukosa darah pada pasien diabetes mellitus tipe Ii rawat jalan di RSUD Karanganyar. Jurnal Kesehatan, 10(1), 75. https://doi.org/10.23917/jurkes.v10i1.5495
27. Marta, H., & Tensiska, T. 2016. Kajian sifat fisikokimia tepung jagung pragelatinisasi serta aplikasinya pada pembuatan bubur instan. Jurnal Penelitian Pangan (Indonesian Journal of Food Research*)*, *1*(1), 14–21. https://doi.org/10.24198/jp2.2016.vol1.1.03
28. Pramitra F. dan Sholihah L. 2025. Hubungan beban glikemik dan imt dengan kadar gula darah pada pasien diabetes melitus tipe 2. Journal Health and Nutrtition, 11(1).
29. Prasetyo, A., Ishartani, D., & Affandi, D. R. 2014. Pemanfaatan tepung jagung (Zea mays) sebagai pengganti terigu dalam pembuatan biskuit tinggi energi protein dengan penambahan tepung kacang merah (Phaseolus vulgaris L). Jurnal Teknosains Pangan, 3(1), 15-25.
30. Purnamasari IW, Putri WDR. 2015. Pengaruh penambahan tepung labu kuning dan natrium bikarbonat terhadap karakteristik flake talas. Jurnal Pangan dan Agroindustri. 3(4):1375–1385.
31. Polnaya, F.J. dan Breemer, R. 2016. Karakteristik sifat kimia dan organoleptik kue kering berbahan dasar pati sagu, ubi kayu, ubi jalar, dan keladi. Jurnal Teknologi Pertanian, 5(1), 1-6. https://doi.org/10.30598/jagritekno.2016.5.1.1
32. Rosania, S. P., Sukardi, Winarsih,S. 2022. Pengaruh proporsi penambahan pati ganyong (canna edulis ker.) terhadap sifat fisiko kimia serta tingkat kesukaan cookies. Food Technology and Halal Science Journal, 5(2), 186-205. htpps://doi.org/10.22219/fths.v5i2.21937
33. Rosida, Dedin Finatsiyatull, Nindya Aulia Putri, and Maghfiroh Oktafiani. 2020. Karakteristik cookies tepung kimpul termodifikasi (xanthosoma sagittifolium) dengan penambahan tapioka. Agrointek 14(1):45–56. http://dx.doi.org/10.21107/agrointek.v14i1.6309
34. Ulmanun L, Pujimulyani D, Kanetro B. 2024. Pengaruh penambahan bubuk curcuma xanthorrhiza roxb dan baking powder terhadap sifat fisik, kimia dan tingkat kesukaan cookies sagu- mocafl. (November 2023):274–294
35. Wahjuningsih, S. B., Septiani, A. R., & Haslina, H. 2018. Organoleptik cereal dari tepung beras merah (oryza nivara) dan tepung kacang merah (Phaseolus vulgaris Linn.). Jurnal Litbang Provinsi Jawa Tengah, 16(2), 131–142. https://doi.org/10.36762/litbangjateng.v16i2.758
36. Wari AT, Muhlishoh A, Nurzihan NC. 2023. Indeks glikemik dan beban glikemik makanan kaitannya dengan kadar ldl dan rlpp pasien diabetes mellitus tipe 2. Jurnal Nutrition Collage. 12(1):61–69.doi:10.4324/9781315104775-11
37. Yasinta, M.R. & Handayani, C.B. 2021. Karakteristik kimia, fisik dan organoleptik cookies tepung mocaf dengan variasi jenis dan konsentrasi lemak. Jurnal Teknologi dan Industri Pangan, 32(1):45-56. https://doi.org/10.32585/jfap.v1i1.1455
38. Daniels Evan. 2023. Pengembangan flakses instan rendah indeks glikemik berbahan jagung manis dan kacang merah serta profil analisis sensorinya. [Tesis]. Fakultas Teknologi Pertanian. IPB. Bogor
39. Endyra F. 2024. Pengembangan bubur instan rendah indeks glikemik berbahan baku talas sutra, jagung manis dan kacang merah. Tesis. Fakultas Teknologi Pertanian. IPB. Bogor.
40. Mayasari, N. 2010. Pengaruh penambahan larutan asam dan garam sebagai upaya reduksi oksalat pada tepung talas (Colocasia esculenta (L.) Schott) [skripsi]. Fakultas Teknologi Pertanian. IPB. Bogor
41. Purwanti M, P J, Kadirman. 2017. Penguapan air dan penyusutan irisan ubi kayu selama proses pengeringan menggunakan mesin cabinet dryer. 3:127–136
42. Rosephin, F. 2010. Mutu dan potensi kukis sebagai pangan fungsional dengan substitusi tepung pisang modifikasi. [Skripsi]. Bogor: Fakultas Teknologi Pertanian. Institut Pertanian Bogor.