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Functional cookies from Ambon banana peel flour: Nutritional content and potential role in preventing preeclampsia

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ABSTRACT

Introduction: Preeclampsia is a serious pregnancy complication that poses risks to both the mother and fetus. One promising preventive approach is the use of functional foods to support maternal health, especially through snacks enriched with beneficial nutrients.

Method: This study aimed to analyze the nutritional content of cookies formulated with Ambon banana peel flour (*Musa paradisiaca*) as a functional snack for the prevention of preeclampsia. A Completely Randomized Design (CRD) was used with four formulations: F0 (control, 100g wheat flour), F1 (70g wheat flour + 30g banana peel flour), F2 (60g wheat flour + 40g banana peel flour), and F3 (50g wheat flour + 50g banana peel flour). Nutritional parameters analyzed included moisture, ash, fat, protein, carbohydrates, and calcium.

Result: The study reveals that using banana peel flour as a substitute for wheat flour in cookies production affects its nutritional composition. The moisture content increased from 10.19^{a} to 11.93^{d}, ash content rose from 2.03^{a} to 4.77^{d}, fat content increased from 13.63^{a} to 14.40^{d}, and calcium levels grew from 76.119^{a} to 91.821^{d} as the proportion of banana peel flour increased. On the other hand, protein content decreased from 12.61^{a} to 10.87^{d}, and carbohydrates declined from 61.54^{a} to 58.04^{c}. These changes demonstrate that substituting wheat flour with banana peel flour influences the nutritional value of the resulting cookies.

Conclusion: Cookies with Ambon banana peel flour resulted in significant micronutrient enhancement, most notably in calcium levels. Scientific evidence indicates that maintaining sufficient calcium consumption (1200-1400 mg daily) during pregnancy may lower preeclampsia risk by modulating vascular tension. The developed product (Formulation F2) containing 84.171 mg/kg of calcium shows promise as a dietary intervention for preeclampsia mitigation, particularly beneficial for populations with inadequate calcium intake

KEYWORDS

Calcium, Food technology, Functional food, macronutrients.

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INTRODUCTION

Preeclampsia is a pregnancy disorder characterized by the onset of hypertension (blood pressure ≥140/90 mmHg) and proteinuria (≥0.3 g in 24-hour urine) after 20 weeks of gestation in previously normotensive women. This condition can progress to a more severe form accompanied by symptoms such as severe headache, visual disturbances, epigastric pain, elevated liver enzymes, low platelet count, or impaired kidney function[1,2].

The Data of World Health Organization (WHO), approximately 2–8% of all pregnancies experience preeclampsia[3]. The Indonesian Health Survey (SKI) data show the highest blood pressure screening rate in Bali (100%) and the lowest in the Papua Highlands (80.3%), with a national average of 99.0%. Based on age groups, the lowest screening rate was among those aged 15–19 years (93.7%) and the highest among those aged 10–14 years. For adolescents aged 10–19 years, the rate was 93.8%, and for women of reproductive age (15–49 years), it was 99.0%. Additionally, the highest proportion of women aged 10–54 years who received complete ANC components according to standards (10 T) during pregnancy was in Bali (87.9%), while the lowest was in North Sumatra (17.4%)[4].

Risk factors for preeclampsia include various obstetric and medical conditions such as first-time pregnancy (nulliparity), multiple pregnancies, obesity, chronic hypertension, diabetes, kidney disease, and a family history of preeclampsia. Moreover, dietary patterns play a significant role; low intake of antioxidants, fiber, vitamin C, and micronutrients such as calcium and magnesium, along with a high sodium-to-potassium ratio, has been associated with an increased risk of preeclampsia[5]. High sodium intake is a significant risk factor for hypertension[6].

Preeclampsia is one of the most feared pregnancy complications. It often appears as new-onset hypertension with proteinuria in the third trimester and can quickly progress into serious complications, including maternal and fetal death. Women with a history of preeclampsia are at increased risk of cardiovascular disease (CVD) and dementia later in life, including fatal acute myocardial infarction[7].

Management solutions for preeclampsia include dietary modifications such as increasing the consumption of fruits and vegetables (≥400 g/day), plant-based foods, vegetable oils, and limiting foods high in fat, sugar, and salt. A high-fiber diet (25–30 g/day) can help reduce dyslipidemia, lower blood pressure, and alleviate inflammation. Other important nutrients that may help reduce the risk of preeclampsia include increased calcium intake, daily multivitamin/mineral supplements, and sufficient vitamin D status. Dietary factors that play a role in reducing the risk of preeclampsia include maternal body weight, fiber, prebiotics, dietary patterns, vitamin D (RDA 15 µg/day), calcium (RDA 1000 mg/day), selenium (RDA 60 µg/day), multivitamins and multiminerals, and body mass index[5].

Previous studies have shown that food products enriched with banana peel exhibit improved nutritional value and functional properties compared to conventional foods. The use of banana peel has several positive impacts: first, it benefits the environment by utilizing by-products from food processing; second, it provides new perspectives for consumers and producers in developing value-added food products[8].

Manulu and Srimiati also demonstrated that cookies made from kepok banana peel flour can be used to produce nutritious cookies. 50% substitution of wheat flour with kepok banana flour was the best formulation preferred by panelists[9].

Bananas are widely favored by consumers for their rich nutritional profile. Despite this, banana peels are often treated as waste and discarded. In reality, banana peels are a valuable source of nutrients such as proteins, carbohydrates, fats, moisture, ash (minerals), starch, dietary fiber, essential fatty acids, amino acids, and antioxidants. They also contain a wide array of bioactive compounds, including phenolic substances like flavonoids, as well as phlorotannins, alkaloids, glycosides, anthocyanins, terpenoids, and various carotenoids such as lutein, alpha-carotene, and beta-carotene. These compounds are associated with a range of biological and pharmacological effects, including antibacterial, antihypertensive, antidiabetic, and anti-inflammatory activities[10,11].

Plant-derived bioactive compounds produced through secondary metabolism are known for their significant therapeutic potential, primarily due to their antioxidant properties. Among these, phenolic compounds and carotenoids are prominent phytochemicals commonly found in fruits and vegetables, and are strongly linked to health benefits[12].

Given these advantages, investigating the development of functional cookies using *Ambon banana peel flour* is important. This research aims to assess the nutritional composition of such cookies and evaluate how it aligns with the dietary requirements of pregnant women, providing a scientific foundation for developing functional foods aimed at preventing preeclampsia.

METHODE

Study Design, Location, and Timeline

This experimental study utilized a Completely Randomized Design (CRD) for cookie formulation. It was conducted from May to November 2024 at Universitas Andalas (Culinary Laboratory, Nutrition Department; Animal Product Technology Laboratory; Faculty of Engineering). This research used informed consent.

Materials and Tools

The main ingredients used in the cookie formulations were wheat flour, margarine, sugar, eggs, and Ambon banana peel flour. Ambon banana peel flour is produced by drying and grinding the peels of Ambon bananas into a fine powder.

The equipment used in the preparation process included stainless steel bowls, pans, cutting boards, knives, blenders, strainers, plastic spatulas, measuring spoons and cups, weighing scales, paper towels, oil filters, frying pans, cooking spatulas, thermometers, packaging materials, and cookie molds. For the nutritional analysis, additional tools such as porcelain crucibles, desiccators, tongs, ovens, analytical balances, sieves, ashing furnaces, Kjeldahl flasks, Soxhlet extractors, electric heaters, and filter papers were utilized. The formulations used in the study (Table 1).

Preparation of Ambon Banana Peel Flour

The process of preparing Ambon banana peel flour involves several sequential steps. First, the peels are cleaned under running water to remove any impurities and then cut into small pieces (around 1 × 0.5 cm) to accelerate the drying process. After slicing, the peels are soaked for 15 minutes in a sodium metabisulfite solution, which helps prevent enzymatic browning and maintains the peel's color and quality. Drying is then performed using a food dehydrator set to 60°C for about 6 hours, or until the moisture content drops to a desired level a method proven to effectively preserve ingredient quality. After drying, the peels are ground using a flour mill and sieved to obtain a fine, consistent powder using an 80-mesh screen[13,14]. Finally,the flour yield is calculated by comparing the weight of the flour produced to the original weight of the fresh peels, using the following formula:

$$\text{Yield (\%)} = \frac{\text{Weight of flour}}{\text{Weight of fresh banana peel}} \times 100$$

Formulation of Ambon Banana Peel Flour Cookies

The experimental design included four treatment levels: F0, F1, F2, and F3. Each formulation incorporated banana peel flour at varying concentrations 0% for F0, 30% for F1, 40% for F2, and 50% for F3[9]. Following the production of the cookies, organoleptic tests were conducted, focusing on hedonic quality to assess sensory characteristics such as color, aroma, taste, and texture. Nutritional analysis was also performed using proximate methods to evaluate the levels of carbohydrates, protein, fat, and calcium in the Ambon banana peel flour cookies. For the product to be classified as a calcium source, it must meet at least 15% of the Recommended Dietary Allowance (RDA), which equates to 567.45 mg of calcium per 100 grams of cookies[15]. The composition of each formulation is shown in Table 1.

The cookie samples were subjected to a hedonic sensory evaluation involving 30 semi-trained panelists, all of whom were nutrition students from the Faculty of Public Health at Universitas Andalas. Panelists were selected based on specific criteria: they had to be in good health, not experiencing hunger at the time of testing, and willing to participate in the sensory assessment. A 7-point hedonic scale was used, where a score of 1 represented strongly dislike and 7 represented strongly like[16]. After the sensory testing, the cookies were analyzed for their nutritional content.

Nutrient Analysis

The evaluation of nutrients in food products is carried out through proximate analysis. This includes the measurement of moisture, ash, fat, protein, carbohydrates, and calcium contents.

a. Moisture

Moisture content in the sample was determined using the gravimetric oven-drying method at 105 °C. The sample was first weighed, then dried in an oven at 105 ± 2 °C for 4 to 6 hours or until a constant weight was achieved. This method is based on the principle that water in the sample evaporates during heating, and the reduction in weight reflects the moisture content[17]. The moisture content was calculated using the following formula:

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Table 1. Cookies Formula with Ambon Banana Peel Flour

Ingredients (g)	Treatment			
	F0 (0%)	**F1 (30%)**	**F2 (40%)**	**F3 (50%)**
Ambon banana peel flour	0	30	40	50
Wheat flour*	100	70	60	50
Cornstarch	10	10	10	10
Egg yolk	35	35	35	35
Butter	30	30	30	30
Granulated sugar	50	50	50	50
Milk chocolate bar	15	15	15	15
Baking Powder	1	1	1	1
Skim milk powder	50	50	50	50
Total	291	291	291	291

*Banana peel flour is a substitute for wheat flour. F0 (control – 100g wheat flour), F1 (70g wheat flour + 30g banana peel flour), F2 (60g wheat flour + 40g banana peel flour), and F3 (50g wheat flour + 50g banana peel flour).

b. Ash

Ash content was determined by incinerating the sample in a muffle furnace at 550 °C. The sample was first dried and then incinerated at high temperature until all organic matter was completely decomposed, leaving only inorganic residue as ash. This method measures the total mineral content in food by complete combustion[17]. Ash content was calculated as:

$$\text{Kadar abu (\%)} = \frac{\text{Berat abu}}{\text{Berat sampel awal}} \times 100$$

c. Fat

Fat content was measured using the Soxhlet extraction method, a standard technique for determining total fat in food. Fat was continuously extracted from the sample using a non-polar solvent such as petroleum ether or n-hexane for 6 to 8 hours. The sample was placed in a thimble, and the solvent was repeatedly vaporized and condensed to wash over the sample. After extraction, the solvent was evaporated, and the remaining fat was weighed[17]. Fat content was calculated using:

$$\text{Fat (\%)} = \frac{\text{Fat weight}}{\text{Sample weight}} \text{ x } 100$$

d. Protein

Protein content was analyzed based on nitrogen determination. Nitrogen in the sample was converted to ammonium sulfate, distilled into ammonia, and titrated. The nitrogen content was then multiplied by a conversion factor (typically 6.25) to estimate total protein[17]. The formula used was:

$$\text{Protein (\%)} = \text{Nitrogen content} \times 6.25$$

e. Carbohydrates

Carbohydrates were calculated indirectly by the difference method, subtracting the sum of other components (moisture, ash, protein, fat, and crude fiber) from 100% (AOAC, 2019)[17]:

$$\text{Carbohydrates (\%)} = 100 - (\text{Moisture} + \text{Ash} + \text{Protein} + \text{Fat} + \text{Fiber})$$

f. Calcium

Calcium concentration (Ca) was measured using Atomic Absorption Spectrophotometry (AAS). The sample was digested (via dry or wet ashing), then atomized in a flame, and absorbance was measured at a calcium-specific wavelength (~422.7 nm). The absorbance was compared to a calcium standard curve[17].

Data Analysis

The normality of the data was assessed using the Shapiro-Wilk test, with a p-value greater than 0.05 indicating a normal distribution. Nutritional composition data were then analyzed using a One-Way ANOVA, followed by Duncan's multiple range test for post hoc comparisons[18]. All tests used $\alpha = 0.05$ and SPSS v26. The workflow is shown in Figure 1.

RESULT

Physical Characteristics of Ambon Banana Peel Flour

The Ambon banana peel flour analyzed in this study was assessed for its suitability as a functional component in the formulation of food products. The flour demonstrated a smooth texture with consistently sized particles, attributed to efficient drying and grinding methods. Its color varied from light to yellowish brown, a characteristic that could influence the visual appeal of end products like cookies. Ambon Banana peel Flour (Figure 2)

Characteristics of Cookies Made with Ambon Banana Peel Flour

Cookies were prepared using varying levels of wheat flour substitution with Ambon banana peel flour, specifically at 0%, 30%, 40%, and 50%. The results indicated that using 40% and 50% substitution levels led to a darker brown coloration and a firmer texture in the cookies (Figure 3).

Nutritional Analysis of Cookies with Ambon Banana Peel Flour

Incorporating Ambon banana peel flour resulted in a notable increase in the levels of moisture, ash, fat, and calcium in the cookie formulation. Detailed nutrient analysis results are provided in Table 2.

The F3 formulation showed the highest levels of moisture, ash, fat, and calcium, while F0 had the lowest levels of these nutrients. Conversely, protein and carbohydrate contents were highest in F0 and lowest in F3. A significant correlation was observed between the substitution of wheat flour with banana peel flour and the contents of moisture, ash, fat, and calcium ($p < 0.05$). The substitution also led to significant differences in the nutritional composition of the cookies.

Comparative Analysis of Nutrient Content in the Best Banana Peel Flour Cookie Formulation (F2)/100 g with SNI (Indonesian National Standard) and RDA (Recommended Dietary Allowance)

The F2 formulation complies with the SNI standards for fat and protein content. Additionally, it provides at least 10% of the Recommended Dietary Allowance (RDA) for protein, fat, and carbohydrates for women in their first trimester of pregnancy[19]. The evaluation focuses on essential nutrient parameters, including protein, fat, carbohydrates, calcium, moisture, and ash content (Table 3).

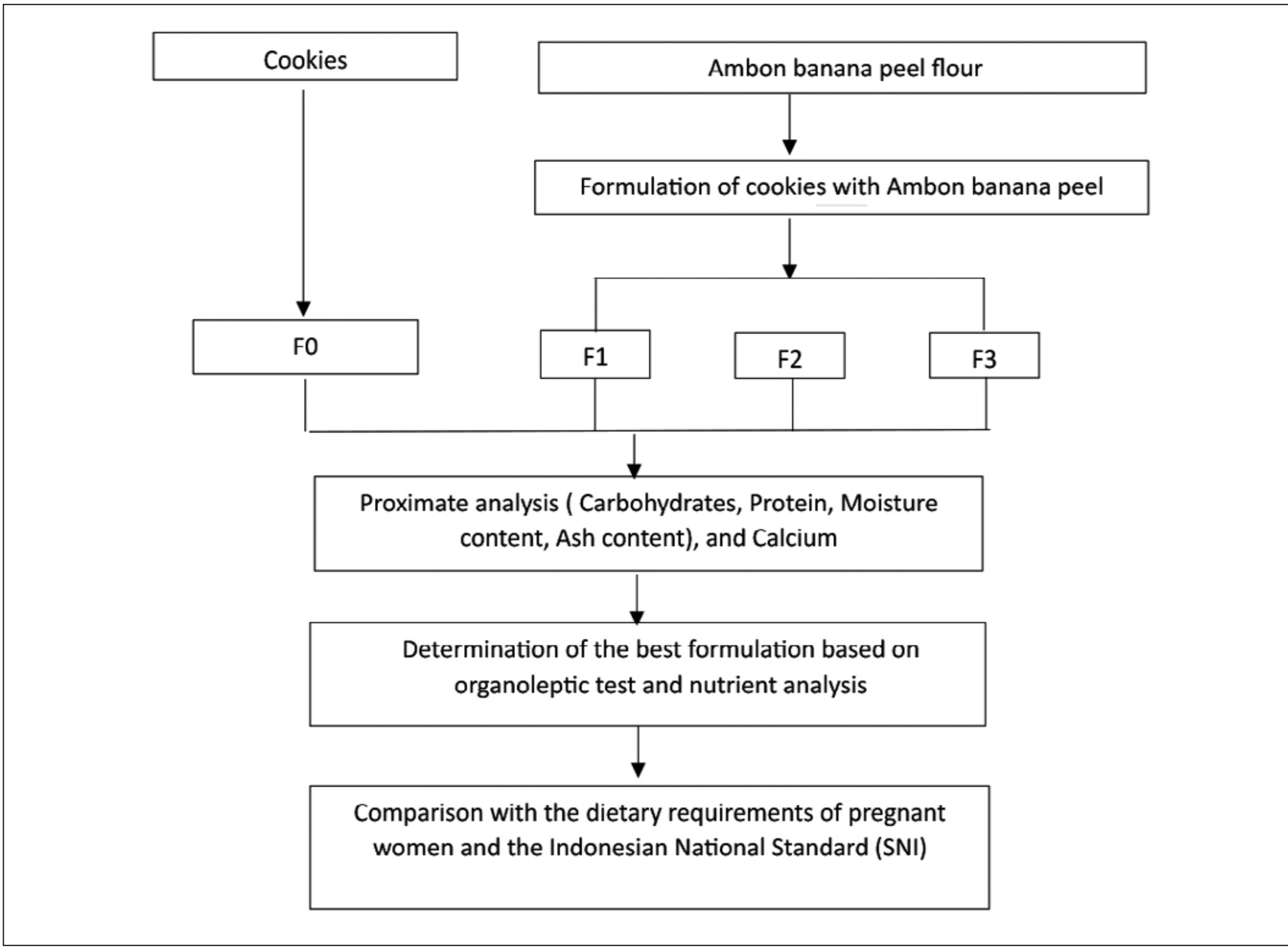


Figure 1. Research Flow Diagram

Table 2. Results of Nutritional Content Analysis of Cookies with Ambon Banana Peel Flour

Parameter	Treatment Levels				Sig (*p*)*
	F0	F1	F2	F3	
Moisture (%)	10.190^{a}	11.890^{b}	10.860^{c}	11.930^{d}	0.0001
Ash (%)	2.030^{a}	3.600^{b}	4.460^{c}	4.770^{d}	0.0001
Fat (%)	13.630^{a}	13.850^{b}	14.040^{c}	14.400^{d}	0.0001
Protein (%)	12.610^{a}	11.460^{b}	11.250^{c}	10.870^{d}	0.0001
Carbohydrate (%)	61.540^{a}	59.210^{b}	59.400^{b}	58.040^{c}	0.0001
Calcium (mg/kg)	76.119^{a}	77.047^{b}	84.171^{c}	91.821^{d}	0.0001
Total	176.110	177.050	184.180	191.830	

F0 = standard formula (100 g wheat flour), F1 = 70 g wheat flour + 30 g banana peel flour, F2 = 60 g wheat flour + 40 g banana peel flour, and F3 = 50 g wheat flour + 50 g banana peel flour.
*ANOVA test showed a significant difference (p-value < 0.05).
Superscript letters (a, b, c, d) that differ indicate statistically significant differences at the 5% level according to Duncan's multiple range test.

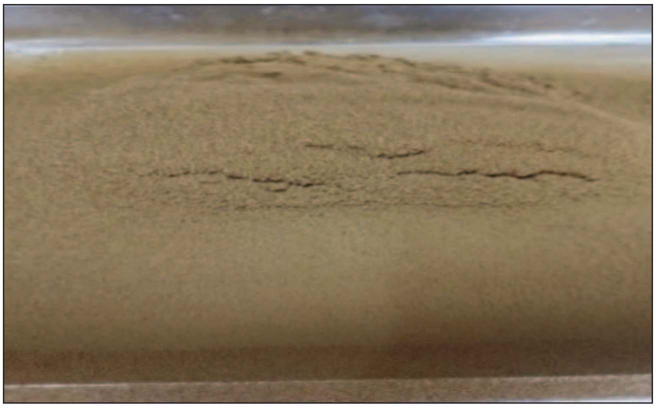


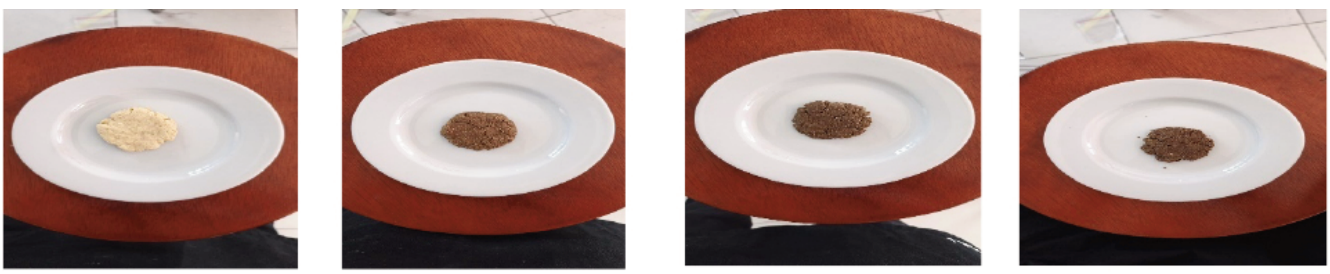
Figure 2. Ambon Banana Peel Flour

DISCUSSION

Physical Characteristics of Ambon Banana Peel Flour

Banana peel flour was chosen due to its rich content of dietary fiber, essential minerals like calcium and potassium, and high levels of antioxidant bioactive compounds. These components are believed to support nutritional improvement and help lower the risk of hypertension in pregnant women[8,10,11].

The flour obtained in this study featured a smooth texture, a characteristic aroma of Ambon banana, and a light brown hue (Figure 2). 1,810 grams of Ambon banana peel were processed into 442 grams of flour, resulting in a yield of 15.7%.



F0
(100g wheat flour),

F1
(70g wheat flour + 30g banana peel flour)

F2
(60g wheat flour + 40g banana peel flour)

F3
(50g wheat flour + 50g banana peel flour)

Figure 3. Cookies with Ambon Banana Peel Flour

Table 3. Presents a comparison between the best formulation of cookies made with banana peel flour (F2) with SNI 2973-2011, and RDA for pregnant women

Parameter	F2	SNI		Pregnant Women's Nutritional Requirements 10% RDA			
		Requirements (%)	Description	T1	T2	T3	Description
Moisture (%)	10,86	Maks 5	Not suitable	-	-	-	-
Ash (%)	4,46	Maks 1,6	Not suitable	-	-	-	-
Fat (g)	14,04	Min 5	suitable	6,73	6,73	6,73	suitable
Protein (g)	11,25	Min 9,5	suitable	6,1	7	9	suitable
Carbohydrate (g)	59,40	Min 70	Not suitable	38,5	40	40	suitable
Calcium (mg/kg)	84,171	-	-	120	120	120	Not suitable

F2 (60g wheat flour + 40g banana peel flour). T1 = pregnant women in the first trimester.

Conversely, Rahayu and Hudi found that the average yield of kepok banana flour ranged from 34.61% to 35.56[14]. Producing banana flour serves to maximize the potential of bananas as a local carbohydrate source, contributing to food security, while also promoting banana-based flour products to the commercial market as an alternative to wheat flour for making cookies, bread, and other baked goods[20].

Characteristics of Cookies Made with Ambon Banana Peel Flour

Variations in the nutritional composition are strongly influenced by the chemical properties and functional attributes of banana peel. This ingredient serves as an alternative source that is rich in fiber and minerals, as shown in Table 2.

These results align with previous findings on sweet buns where wheat flour was partially replaced with banana peel flour, showing notable changes in both physical and chemical properties, particularly at substitution levels of 5% and 10%. The inclusion of banana peel flour (BPF) led to increased levels of minerals and crude fiber, due to its naturally higher ash and fiber content compared to wheat flour. Consequently, the texture of the buns became denser, as the higher fiber content absorbed more moisture and created a firmer dough during baking[21].

Furthermore, buns with BPF substitution exhibited a darker color than the control samples. This was attributed to the natural pigments in the banana peel and the Maillard reaction during the baking process. The resulting color leaned toward a deep reddish-yellow, which is characteristic of BPF. This visual change became more pronounced at the 10% substitution level. Although the nutritional quality improved, these changes in appearance and texture are crucial considerations for ensuring consumer acceptance[21]. The nutritional content analysis of Ambon banana peel flour cookies is presented in Table 2.

Nutritional Analysis of Cookies with Ambon Banana Peel Flour

Incorporating Ambon banana peel flour into the cookie formulation significantly influenced the nutritional profile of the final product. Moisture, ash, fat, and calcium levels increased, while protein and carbohydrate levels decreased (Table 2).

Moisture Content

The moisture content observed in this study increased with higher levels of Ambon banana peel flour, reaching 11.93% in F3 and 10.19% in F0. These findings differ from those of Nur and Naemaa, whose study on bread made with banana peel flour as a wheat flour substitute showed a decrease in moisture content from 9.28±1.70^a to 6.55±1.17^a [21].

The variation in moisture content of banana peel flour may be attributed to differences in the banana cultivars used. Moisture content is a critical factor in food products as it influences various characteristics, including density, viscosity, shelf life, as well as taste, texture, and appearance. Additionally, lower moisture content helps prevent microbial growth by inhibiting enzymatic activity and microbial development. According to Alam *et al*. maintaining flour moisture content below 14% is effective in suppressing microbial growth, thereby enhancing product stability and extending shelf life—particularly for dry ingredients like flour[22].

Ash Content

The ash content increased steadily across all formulations, with the highest value recorded in F3 (4.77%) and the lowest in F0 (2.03%). These results are consistent with those reported by Liyana and Naemaa, who found that the ash content increased significantly from 2.41±0.53b to 8.37±0.27a in bread where banana peel flour was used to replace wheat flour.

Ash content in flour refers to the amount of mineral residue left after combustion at high temperatures. Generally, a higher ash level indicates that the flour has undergone minimal refinement and retains more bran, serving as a marker of both flour purity and milling efficiency. It also signifies the presence of various anatomical parts of the grain, such as the germ, bran, and endosperm[23]. Consequently, banana peel flour is inferred to have a greater mineral concentration than wheat flour.

Fat Content

Fat content increased incrementally as more banana peel flour was incorporated, ranging from 13.63% in F0 to 14.40% in F3. These results are consistent with the findings of Manulu and Srimiati, who reported that substituting wheat flour with banana peel flour significantly increased the fat content of cookies, from 24.25 to 25.52. This increase is attributed to the higher fat content in fresh Ambon bananas, which are processed into banana peel flour, compared to the fat content in wheat flour[9].

Protein Content

A decline in protein content was observed with increased banana peel flour, dropping from 12.61% in F0 to 10.87% in F3. Further supporting evidence comes from research by Manulu and Srimiati, which documented a reduction in protein levels from 5.53 to 5.12 in cookies where banana peel flour replaced wheat flour[9]. This nutritional difference stems from the contrasting protein contents between wheat flour and Ambon banana flour.

The observed decrease aligns with the inherent nutritional profiles of these ingredients, where wheat flour naturally contains significantly higher protein levels compared to banana-based alternatives. This substitution effect highlights the importance of considering nutritional trade-offs when modifying traditional baking ingredients.

Carbohydrate Content

This reduction is attributed to the decreased proportion of wheat flour, a major source of carbohydrates. Wheat flour typically contains a high level of carbohydrates, around 73–76% of its dry weight[24]. When part of the wheat flour is substituted with banana peel flour, the overall carbohydrate content in the product tends to decline. This is because banana peel flour has higher levels of crude fiber and ash (minerals), but lower starch content—the primary form of carbohydrates. As a result, increasing the proportion of banana peel flour generally leads to a decrease in the carbohydrate content of the cookies.

Carbohydrate levels showed a downward trend, declining from 61.54% in F0 to 58.04% in F3. These findings contrast with those of Manulu and Srimiati, who observed a notable rise in carbohydrate content, increasing from 66.24 to 66.60, in cookies where wheat flour was partially replaced with banana peel flour[9].

Calcium Content

Calcium concentration increased in line with higher levels of banana peel flour, reaching 91.821 mg/100 g in F3 and 76.119 mg/100 g in F0. Nur and Naemaa also observed a comparable outcome, where replacing wheat flour with banana peel flour in bread led to an increase in calcium content, rising from 41±0.89b to 101.5±0.82a. This higher calcium level in the banana peel flour (BPF)-substituted bread is likely attributed to the greater mineral content of banana peel flour relative to that of wheat flour[21].

Comparative Analysis of Nutrient Content in the Best Banana Peel Flour Cookie Formulation (F2)/100 g with SNI (Food Quality Regulations) and RDA (Recommended Dietary Allowance)

Nutritional evaluation of the optimized cookie formulation (F2), incorporating Ambon banana peel flour, demonstrated that its fat and protein contents comply with the quality standards outlined in SNI[25]. Based on RDA, pregnant women require approximately 70–90 g of protein per day, with snacks ideally contributing 10–20 g, or around 15–20% of the total daily intake[19]. One batch of F2 dough (291 g) produced 19 cookies. A 100 g serving of these cookies contains roughly eight pieces, each with a diameter of approximately 6 cm. It was calculated that consuming 4.34 cookies would sufficiently meet the protein requirements of women in their first trimester of pregnancy. This suggests that the F2 cookies have strong potential to function as a nutritionally supportive snack for expectant mothers.

CONCLUSION AND SUGGESTION

The banana peel flour-based cookie formulation provides sufficient levels of calcium, protein, carbohydrates, and fat to help fulfill the nutritional demands of pregnancy. Its protein and fat composition adheres to existing food quality regulations (SNI). With a well-balanced nutrient profile, these cookies may contribute to improved maternal nutrition and potentially aid in reducing the risk of preeclampsia. Sensory evaluation also confirmed that the product was generally well-received by panelists, reinforcing its viability as a functional food option for pregnant women.

Including approximately 4.34 cookies in the daily diet may support first-trimester protein intake when consumed as a functional snack. Continued research and development are recommended, focusing on enhancing nutritional value, ensuring formulation stability, and improving consumer acceptability, to enable broader use of this product as a maternal health-supportive food innovation.

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