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Differences in Nutritional Quality, Resistant Starch, and Fiber of Mangpis Cookies Made from Lindur Flour (Bruguiera Gymnorhiza) and Saba Banana Flour (Musa Paradisiaca L.)

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Abstract

Obesity and diabetes mellitus remain major global health challenges associated with unhealthy dietary patterns, excessive energy intake, and inadequate fiber consumption. The development of functional food products containing dietary fiber and resistant starch is considered an effective nutritional strategy to support metabolic health. This study aimed to determine differences in nutritional quality, resistant starch content, and fiber characteristics of Mangpis Cookies formulated with lindur fruit flour (Bruguiera gymnorhiza) and kepok banana flour (Musa paradisiaca L.). This research used a laboratory experimental method with a completely randomized design consisting of four formulations: F0 (100% wheat flour), F1 (70% lindur flour:30% kepok banana flour), F2 (50% lindur flour:50% kepok banana flour), and F3 (30% lindur flour:70% kepok banana flour). Nutritional composition analysis included moisture, ash, protein, fat, carbohydrate, energy, resistant starch, crude fiber, and dietary fiber using standard analytical methods. The results showed that flour substitution significantly affected all nutritional parameters ($p<0.05$). Formula F1 demonstrated the highest functional nutritional characteristics, with resistant starch content of 8.10%, crude fiber of 7.64%, and dietary fiber of 9.06%. The findings indicate that lindur flour contributes substantially to increasing fiber and resistant starch levels in cookies, while kepok banana flour contributes to mineral content and nutritional diversification. In conclusion, Mangpis Cookies formulated with lindur and kepok banana flour have potential as a functional food product with improved nutritional properties, particularly for supporting healthier dietary patterns and metabolic health management.

INTRODUCTION

Obesity and diabetes mellitus (DM) are still public health issues that receive widespread attention, both globally and nationally. The World Health Organization (WHO) reported that in 2016 the prevalence of obesity in the adult group over 18 years old reached 13%, while the proportion of overweight reached 39% (World Health Organization, 2016). In Indonesia, the prevalence of obesity continues to increase until it reaches 21.8% in 2018 (Ministry of Health of the Republic of Indonesia, 2018). In the same year, the prevalence of DM in the population aged over 15 years was recorded at 10.9%, higher than the 2013 results. DM is a metabolic disorder related to the metabolism of carbohydrates, fats, and proteins, and can occur due to impaired insulin secretion, insulin resistance, or a combination of both. This condition is at risk of causing serious complications such as heart disease, kidney failure, stroke, and various other health problems (DeFronzo et al., 2015; Rajput & Siddiqui, 2015).

Obesity is one of the important risk factors for DM. This condition generally arises due to an imbalance between the incoming energy and the energy expelled by the body (Téllez-Rojo et al., 2019). Lifestyle changes, increased consumption of ready-to-eat foods and beverages, ease of ordering technology-based food, decreased physical activity, gut microbiota dysbiosis, micronutrient imbalances, and low fiber intake are factors that contribute to an increased risk of obesity and metabolic disorders (Ciobârcă et al., 2020; Diering et al., 2021; Vamanu & Rai, 2018). Therefore, glycemic control needs to be carried out through lifestyle improvements, one of which is by increasing fiber consumption and implementing a low-calorie diet (Pasmans et al., 2022).

Nutritional strategies to maintain glycemic control can be carried out through restricting carbohydrate intake, selecting carbohydrate sources with low glycemic index and load, consumption of foods that can inhibit glucose absorption in the intestines, meal timing, and increasing fiber consumption (Abutair et al., 2016). Dietary fiber plays a role in increasing satiety, suppressing hunger, reducing energy intake, and increasing the viscosity of the digestive tract. These conditions can slow down the absorption of macronutrients and help lower glycemia after meals. In addition, fiber is also associated with increased release of the hormone's cholecystokinin, GLP-1, ghrelin, and PYY (Nie & Luo, 2021; Yang et al., 2022). At the molecular level, fiber affects the activity of HMG-CoA reductase, LDL receptors, AMPK signaling pathways, as well as genes associated with fat metabolism (Saboo et al., 2022).

Fermentation of fiber in the intestines produces short-chain fatty acids (SCFAs) that can help suppress liver glucose production and free fatty acid levels. This mechanism makes fiber an important component in the management of obesity and DM. The recommended fiber intake ranges from 25–40 g per day and can be obtained from food sources such as cereals, vegetables, fruits, and certain supplements (Rosyadi et al., 2014).

Mangpis Cookies is a cookie product that utilizes lindur type mangrove fruit flour (Bruguiera gymnorhiza) and kepok banana flour (Musa paradisiaca L.). Lindur fruit is one of the mangrove products that is widely found in coastal areas of Indonesia and has the potential as an alternative food ingredient because of its fiber content. This fruit has been processed into various products, such as flour, biscuits, cookies, crackers, pancakes, cakes, analog rice, brownies, and dodol. Some studies have also shown that after proper processing, the tannins and cyanide acid content in lindur fruit are at levels that are safe for consumption (Rahayu et al., 2022; Rosulva et al., 2021). In addition to the fruit, other parts of the Bruguiera gymnorhiza plant, such as the leaves, roots, and stems, have also been traditionally used because they have antifungal, antibacterial, anti-inflammatory, and antioxidant activity.

In terms of composition, lindur fruit has a carbohydrate content of 94.03% and starch of 67.75%. The high content of carbohydrates and starches makes lindur fruit have the opportunity to be developed as an alternative flour source in Indonesia. Lindur flour was also reported to contain 31.56% amylose and 26.17% amylopectin (Budiman et al., 2018; Wahyuni & Paramita, 2015).

In addition to lindur, kepok bananas are also known as a food ingredient that contains fiber, antioxidants, inulin, and resistant starch (Afzal et al., 2022). Bananas have pharmacological potential as an anti-inflammatory, antioxidant, anticancer, and antidiabetic food ingredient

(Amalia et al., 2022). One medium-sized banana can contain about 6 g of fiber, 450–467 mg of potassium. Banana flour substitution in biscuit products reportedly has the potential to help lower blood sugar levels by inhibiting free radicals and reducing lipid peroxidation in tissues. Resistant starch in bananas is reported to reach 27.7% (Rosalina et al., 2018).

Higher levels of resistant starch in banana flour can improve prebiotic properties and lower the glycemic index. For example, hydrothermal and retrogradation treatments lead to an increase in resistant starch content, such as pressure treatment at 121 °C followed by the cooling stage (Afifah et al., 2021).

In 100 g of mangrove flour, the reported nutritional composition included 3.17% water, 0.64% fat, 4.86% protein, 89.71% carbohydrates, 1.64% ash content, and 23.43% dietary fiber (22). Meanwhile, banana flour has a moisture content of 9.64%, fat 0.5%, protein 3.1%, carbohydrate content of 84.96%, ash content of 1.8%, and fiber content of 1.8% (Indonesian Food and Drug Control Agency, 2016). Based on this potential, this study was conducted to identify differences in the quality of nutritional value, resistant starch content, and cookie fiber content The ingredients used in this cake are ladur flour and banana kepok flour. The parameters of the observed nutritional value were water content, ash content, protein, fat, carbohydrates, energy, crude fiber, dietary fiber, soluble fiber and insoluble fiber.

Several previous studies have explored the incorporation of mangrove flour and banana flour into food products. Research by Afifah et al. (2021) investigated cookies made from mangrove fruit (Bruguiera gymnorrhiza) and soybean flour, demonstrating the feasibility of mangrove-based ingredients in functional food development. Another study by Rosulva et al. (2021) discussed the potential of mangrove fruits as alternative food sources, emphasizing their nutritional and technological applications. Meanwhile, research regarding banana flour substitution has shown improvements in resistant starch content and functional characteristics of food products. However, most previous studies have examined mangrove flour or banana flour separately, while limited studies have evaluated the combined substitution effect of lindur flour and kepok banana flour on comprehensive nutritional parameters in cookie products.

Although previous research has provided valuable insights into the nutritional potential of lindur and banana flour, several research gaps remain. Existing studies have not sufficiently explained how different combinations of lindur flour and kepok banana flour influence nutritional quality indicators simultaneously, particularly energy content, macronutrient composition, resistant starch, crude fiber, and dietary fiber. In addition, the optimization of functional cookie formulations using these two local ingredients requires further investigation to determine whether the resulting product meets nutritional standards while maintaining its functional benefits. Therefore, systematic evaluation of Mangpis Cookies formulations is necessary to provide scientific evidence regarding the most suitable composition of alternative flour sources.

The urgency of this research is strengthened by the increasing demand for functional foods that can support disease prevention while utilizing sustainable local resources. Developing food products from mangrove and banana-derived ingredients not only contributes to nutritional improvement but also supports diversification of Indonesian food sources and the utilization of underexplored coastal biological resources. Functional snack products such as cookies have high potential for consumer acceptance because they are widely consumed, practical, and easy to distribute. Therefore, improving the nutritional characteristics of cookies through the incorporation of lindur flour and kepok banana flour represents an important strategy for producing healthier food alternatives.

The novelty of this study lies in the formulation of Mangpis Cookies using a combination of lindur flour (Bruguiera gymnorhiza) and kepok banana flour (Musa paradisiaca L.) and evaluating their effects on multiple nutritional indicators, including resistant starch and dietary fiber content. Unlike previous studies that mainly focused on single-ingredient substitution or general product development, this research provides comparative evidence regarding different formulation treatments and their influence on functional nutritional characteristics. The findings are expected to contribute new knowledge regarding the development of locally sourced functional foods with potential applications in nutritional management strategies.

Therefore, this study aims to determine differences in nutritional quality, resistant starch content, and fiber characteristics of Mangpis Cookies produced from varying proportions of lindur flour and kepok banana flour. The research is expected to provide scientific contributions to food science, nutrition, and functional food development by demonstrating the potential of indigenous Indonesian ingredients as alternative sources for healthier food products. Furthermore, the results may benefit researchers, food industries, and communities by providing a reference for developing high-fiber and resistant starch-based snacks that support healthier dietary patterns while promoting sustainable utilization of local resources.

METHOD

The research method used a laboratory experimental design with a complete random design of one factor. In total, there were four formulation treatments that applied two iterations to each treatment. The pastry formulation is arranged based on a mixture of wheat flour, lindur flour, and kepok banana flour with a ratio: (F0 100:0; 70:30); F1 (F2:50; 50); f3 (0/30/40)). Table 1 shows the ingredient composition for each formula. The analysis of the nutritional value of the research was carried out at the Chem-Mix Pratama Laboratory in Bantul, Yogyakarta. The results of the analysis were then compared with with reference limits including energy of at least 400 kcal, protein of 8–12 g, maximum moisture content of 5%, and dietary fiber of 6 g/100 g (24.25). The research was carried out for one month, namely in January-February 2023.

Flour ingredients and manufacture

The raw material for lindur flour is obtained from lindur fruit with the characteristic purplish-dark green color, about 15–30 cm long, and 1–2 cm wide. You wash the fruit, boil it for 15 minutes with the water, peel it, then change it every six hours. After that, the fruit is thinly sliced and dried in the sun for approximately 36 hours until dry. Dried lindur fruit is ground using a grinding machine and sifted with an 80-mesh sieve (Alifianita & Sofyan, 2022; Amalia et al., 2022; Sagita & Febriyani, 2022).

The manufacture of banana kepok flour using raw yellow kepok bananas is about 90 days old. The bananas are peeled, thinly sliced, Dry again in a dehydrator oven at 70°C for three hours, then store. The dried bananas are then ground and sifted with an 80-mesh sieve.

Making Mangpis cookies

To make the cake, margarine, Yakult milk powder, powdered sugar, eggs, and flour are mixed with the treatment formula. The round shape is made from the dough that has been mixed and then flattened, then baked for forty minutes in the oven at 150°C with variations from Afifah et al. (2021).

Table 1. Composition of Mangpis cookies

Ingredients	F0 (100:0:0)	F1 (0:70:30)	F2 (0:50:50)	F3 (0:30:70)
Wheat flour (g)	50	0	0	0
Lindur flour (g)	0	35	25	15
Kepok banana flour (g)	0	15	25	35
Butter (g)	20	20	20	20
Milk powder full cream (g)	10	10	10	10
Refined sugar (g)	25	25	25	25
Egg (Item)	1	1	1	1
Cornstarch (g)	10	10	10	10

RESULTS AND DISCUSSION

Table 2. Quality of nutritional value of Mangpis cookies in 100 g

Parameter	F0	F1	F2	F3	P value
Energy (kkal)*	454,18	415,34	428,58	432,91	0,000
Water (%)*	4,89	8,27	7,66	6,27	0,000
ash content (%)*	1,56	1,78	1,95	2,20	0,000
Protein (%)*	9,61	7,52	6,51	6,06	0,000
Fat (%)*	19,46	18,33	19,64	18,89	0,000
Carbohydrate (%)*	61,57	56,46	57,93	61,31	0,000
Starch resistant (%)*	2,40	8,10	6,64	5,76	0,000
Coarse Fiber (%)*	2,92	7,64	6,32	5,27	0,000
Dietary fiber (%)*	3,39	9,06	7,86	6,63	0,000

Evaluate nutritional value in looking at quality based on the amount of energy, water, ash, protein, bad fats, carbohydrates, resistant starches, coarse fiber and dietary fiber. The analysis is conducted using the AOAC 2005 method. The Kjeldahl method is used to analyze protein, the Soxhlet method is used to analyze fat, the carbohydrate by difference method is used to analyze carbohydrate, and the bomb calorimeter method is used to analyze energy. Shapiro-Wilk is used to assess the normality of data distribution. The differences between moisture content, ash content, protein, fat, carbohydrates, energy, starch resistant, crude fiber, dietary fiber, insoluble fiber, and soluble fiber between treatments are analyzed using a one-way ANOVA.

Moisture content

The results of the analysis indicate that the highest air pressure is found in Formula F1 (0:70:30), which is a flour formula with a composition of 70% lindur and 30% banana kepok. The lowest moisture content is found in F0 (100:0:0), which is a formula based on 100% wheat flour without the addition of lindur and banana flour. Compared to formulas based on banana flour and wheat flour, the moisture content of cookies that uses lindur flour tends to be higher. According to SNIO01-2973-1992, the minimum cookie water rate is 5%. Accordingly, only F0 violates the aforementioned standard, while F1, F2, and F3 have air rates that violate the standard. The results of the ANOVA test indicate that there is a difference between the formula and the air kukis Mangpis ($p=0.000$; $p<0.05$). The high water in a formula with lindur flour is thought to be added is related to the fiber content in that substance. Lindur flour has quite a high content of dietary fiber and crude fiber (Prianggi et al., 2014). The total dietary fiber in lindur flour was reported to be around 23.43%, consisting of 23.07% insoluble fiber and 0.37% soluble fiber. Fiber has the ability to bind water so strongly that water is more difficult to evaporate during the drying or baking process. In addition, fibers composed of cellulose components have hydroxyl groups that can form hydrogen bonds and increase water absorption ability.

Ash content

The highest ash content was found at F3 (0:30:70), which is the formula with the highest proportion of kepok banana flour, while the lowest ash content was found at F0. These results show that the use of kepok banana flour contributes more to ash content than lindar flour. The ANOVA test showed a significant difference in ash content between formulas ($p=0.001$; $p<0.05$). Ash content describes the amount of minerals contained in a food product. Thus, the high ash content in F3 indicates that kepok banana flour contributes greater minerals to Mangpis cookies than lindur flour.

Minerals contained in lindur flour and banana flour include calcium, phosphorus, zinc, potassium, magnesium, iron, sodium, and copper. In the body, minerals act as enzyme activators, custodians of osmotic balance, as well as important components in the maintenance of physiological functions. Certain mineral deficiencies can have health impacts, such as iron deficiency associated with anemia and iodine deficiency associated with thyroid gland disorders. Minerals are essential elements needed to maintain normal biochemical processes in the body, with macro mineral requirements in adults generally exceeding 100 mg per day.

Protein content

The average protein content of Mangpis cookies ranges from 6.06% to 9.61% per 100 g. F0 formula has the highest protein content, while the protein content in the formula using lindur flour and banana flour is lower. Although an increased proportion of lindur flour tends to result in higher protein levels than banana flour, F1 protein content remains lower than F0. This shows that wheat flour still contributes greater protein than a mixture of lindur flour and banana kepok flour.

Referring to SNI, the protein content of cookies is in the range of 8–10%. Based on these references, most of the Mangpis cookie formulas do not meet the protein content standard, except for F0 which is in the appropriate range. The low protein content in the substitution formula is likely due to the relatively low protein content of lindur flour and banana flour. The type of flour used in the formulation affects the final protein content of the product. In addition, the use of margarine can also affect the proportion of protein in the final product. Protein has an important function as a building agent, a source of energy, and a component that supports the body's defense mechanism against microbes and toxins from the outside.

Fat content

The fat content of Mangpis cookies ranges from 18.33% to 19.64% per 100 g. The highest fat content is found in F2, which is a formula with a composition of lindur flour and banana kepok flour of 50% each. The F1 and F3 formulas produce lower fat levels than F0 and F2. These results suggest that variations in flour composition can affect the fat content of the product, although additional ingredients such as eggs and margarine also contribute to the fat content of cookies.

When compared to SNI, the fat content of cookies is 10–18%. All Mangpis cookie formulas in this study have fat levels that are slightly above this standard. The suspected cause is the use of egg yolks and margarine in the formulation, as these two ingredients are quite dominant sources of fat in the making of cookies.

Carbohydrate content

The carbohydrate content of Mangpis cookies is in the range of 56.46% to 61.57% per 100 g. Formula F0 shows the highest carbohydrate content, followed by F3, while the lowest carbohydrate content is found in F1. This data shows that the higher the addition of lindur flour, the carbohydrate content tends to decrease. On the other hand, kepok banana flour and wheat flour contribute higher carbohydrates than lindur flour.

Carbohydrates in food are generally found in the form of starch. The result of digestion of carbohydrates in the form of glucose is used as the main source of energy, especially for the brain. Glucose is also a raw material in alpha-ketoglutaric synthesis through the citric acid cycle and plays a role in the synthesis of neurotransmitters. Therefore, carbohydrate content remains an important parameter in the assessment of the nutritional quality of cookie products, especially when the product is developed for groups that need to control the glycemic response.

Energy content

The energy content of Mangpis cookies ranges from 415.34 to 454.18 kcal per 100 g. F0 formula has the highest energy content, while F1 has the lowest energy content. These results show that the greater the proportion of lindur flour in the formula, the energy content tends to decrease. Meanwhile, kepok banana flour provides a higher energy contribution than lindur flour. Based on SNI, the minimum energy standard for cookies is 400 kcal, so all formulas in this study have met these standards.

Starch resistant

The starch content of Mangpis cookies is in the range of 2.40% to 8.10%. F1 formula has the highest levels of resistant starch, while F0 has the lowest levels. These results show that the greater the proportion of lindur flour in the formula, the higher the level of resistant starch produced. Thus, lindur flour contributes more to the resistant starch content than the kepok banana flour in the formulation of Mangpis cookies.

Resistant starch is the part of starch that is not easily hydrolyzed by the enzyme amylase in the small intestine. Resistant starch belongs to the group of resistant starches that are formed during the processing process of this cookie product. Long-lasting patai is widely used as a functional food ingredient because it can be used as a substitute for other foods and some wheat flour, a source of fiber, a low-glycemic index ingredient, gluten-free products, and components that support prebiotic function. Consumption of certain amounts of resistant starches has been reported to have an effect on metabolic profiles, including triglycerides, GLP-1 hormones, TNF-α inflammation, and intestinal production of propionate and butyrate, potentially supporting the management of type 2 diabetes mellitus. In overweight and obese individuals, the administration of 15–30 g of resistant starch per day has also been reported to have an effect on blood sugar levels.

The intrinsic characteristics of starch, such as granule structure, crystal structure, and amylose to amylopectin ratio, as well as the presence of cornstarch components, such as proteins, lipids, and sugars, influence the formation of resistant starches. In addition, the processing process and storage conditions also affect the formation of resistant starch.

Coarse fiber and dietary fiber

The dietary fiber content of Mangpis cookies ranges from 3.39% to 9.06%, while crude fiber ranges from 2.92% to 7.64%. F1 formula produces the highest levels of dietary fiber and crude fiber, while F0 has the lowest levels. This shows that the higher the addition of lindur flour, the higher the dietary fiber and crude fiber contained in the cookie. The fiber content in Mangpis cookies mainly comes from lindur flour, while kepok banana flour also contributes in smaller amounts.

The dietary fiber content in F1, F2, and F3 exceeds 6 g per 100 g. Based on the Regulation of the Head of BPOM in 2016, solid food products can be categorized as high in fiber if they contain at least 6 g per 100 g (25). Thus, F1, F2, and F3 can be categorized as fiber-rich products. Dietary fiber has the potential to be used as a functional food component to help lower hyperlipidemia (42). Increased fiber intake is also associated with better glycemic control, improved insulin sensitivity, and mild inflammatory improvement in people with diabetes mellitus.

Overall, the results of the study show that the substitution of lindur flour and kepok banana flour affects the nutritional composition of Mangpis cookies. Formulas with a higher proportion of lindur flour excel in fiber and resistant starch content, while formulas with higher banana flour tend to increase ash content. However, the moisture content in the substitution formula still exceeds the SNI standard, and the protein content in some formulas still needs to be improved. Therefore, the development of the next formula needs to consider adjustments to the drying process, the composition of protein source ingredients, and the control of fat content so that the product meets quality standards while still having functional value.

CONCLUSION

The results of this study indicated that the substitution of lindur fruit flour (Bruguiera gymnorhiza) and kepok banana flour (Musa paradisiaca L.) significantly affects the nutritional quality, resistant starch content, and dietary fiber characteristics of Mangpis Cookies. The formulation containing lindur flour and kepok banana flour showed differences in energy, moisture, ash, protein, fat, carbohydrate, resistant starch, crude fiber, and dietary fiber contents. Among the tested formulations, F1 (70% lindur flour and 30% kepok banana flour) demonstrated the highest functional nutritional potential, characterized by the highest resistant starch content (8.10%), crude fiber (7.64%), and dietary fiber (9.06%). These findings confirm that the utilization of lindur flour as a local alternative ingredient can improve the functional properties of cookies, particularly in increasing fiber and resistant starch content, which are beneficial for supporting healthier dietary patterns and metabolic health management. Future research is recommended to further optimize the Mangpis Cookies formulation by considering sensory evaluation, shelf-life stability, digestibility characteristics, glycemic index assessment, and consumer acceptance to ensure product feasibility for wider application. Additional studies involving different processing techniques, protein enrichment strategies, and in vivo evaluations are also needed to validate the physiological benefits of resistant starch and dietary fiber from lindur and kepok banana flour. Furthermore, research on the scalability of production and economic feasibility should be conducted to support the development of Mangpis Cookies as a functional food product based on sustainable and locally available Indonesian resources.

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