

NUTRITIONAL CONTENT OF ANALOG RICE FROM SAGO WITH MUNG BEAN PROTEIN AS A SUBSTITUTE FOR PADDY RICE

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Abstract

Analog rice is one of the staple food alternatives developed to support national food diversification and reduce dependence on paddy rice. This study aims to analyze the nutritional content of sago-based analog rice and compare it with that of white rice (*Oryza sativa*) in an equivalent portion of 200 grams. Laboratory analysis showed that sago analog rice contains 756 kcal of energy, 174.8 g of carbohydrates, 2.88 g of protein, 5.16 g of fat, and 1.64 g of ash. Meanwhile, in the same quantity, white rice contains approximately 720 kcal of energy, around 156 g of carbohydrates, approximately 13.6 g of protein, and about 1.2 g of fat. The conclusion of this study is that sago analog rice has higher energy and carbohydrate content but significantly lower protein content compared to white rice. Therefore, although sago analog rice has potential as an energy source and for utilizing local food resources, reformulation with protein-rich ingredients is necessary to enhance its nutritional value. This study supports the development of sago-based analog rice as a strategic food alternative in sago-producing regions, provided that further nutritional enrichment is conducted to make it acceptable as a nutritionally equivalent staple food.

INTRODUCTION

Carbohydrates contribute to high energy intake from simple carbohydrates. Excessive carbohydrate consumption, especially from white rice, is associated with an increased risk of metabolic diseases such as type 2 diabetes mellitus and obesity (Hardinsyah et al., 2020). Therefore, there is a need for food

alternatives with lower carbohydrate content but higher in protein and fiber to support healthier dietary patterns. One emerging innovation is the development of analog rice, an artificial rice formulated from non-paddy ingredients, but with a shape, texture, and consumption method similar to traditional rice.

One promising ingredient is sago (*Metroxylon sagu*), a local carbohydrate source with a relatively lower glycemic index compared to white rice and widely available in Eastern Indonesia (Larasati et al., 2021). Although sago contains complex carbohydrates, it is low in protein and thus needs to be combined with plant-based protein sources. Sago flour (*Metroxylon sagu*) is a significant carbohydrate source with considerable potential for food diversification, particularly as an alternative food source in Indonesia. Sago is high in carbohydrates, making it a suitable substitute for rice in various processed food products. Sago flour also contains fiber, protein, and other nutritional components that are significant in the context of food security and community welfare (Syartiwidya, 2023; Ningtyastuti et al., 2023). As a carbohydrate source, sago flour contains approximately 97% carbohydrates, serving as a primary source of energy.

Studies report that the crude protein content of sago flour ranges between 1.6% and 2.0%, with moisture content reaching up to 14% (Muslim et al., 2023). Although sago is primarily known for its carbohydrate content, it still offers essential nutritional elements. In culinary applications, sago flour is used as a substitute or additive in other food products, enhancing flavor and nutritional value (Heryani & Silitonga, 2018). Promoting the use of sago flour as a carbohydrate source in food products is evident in community awareness efforts highlighting its potential and nutritional value. Through training and outreach, the community is encouraged to expand the use of sago flour in various preparations such as cakes, pasta, and other food products (Ayu et al., 2024). This can also provide more nutritious food alternatives aligned with the need to reduce reliance on rice and wheat-based products.

Sago also has health benefits, such as the potential for a lower glycemic impact compared to rice, making it a better option for individuals managing their carbohydrate intake (Warsito & Sadiyah, 2019). The development of sago-based food products aligns with efforts to maintain national food security and reduce dependence on imported food ingredients (Swastiwi, 2021). In addition, Indonesia's high sago production holds great potential to support both local and global food policy, especially in food-insecure regions (Derosya & Kasim, 2017). Overall, sago flour is not only a promising alternative staple food but also plays a key role in food diversification and improving community nutrition. With innovative usage, the availability and consumption of sago flour can be increased, maximizing its benefits for the population.

Analog rice is an alternative product made from non-rice sources, and sago flour is one of the most promising candidates due to its high carbohydrate content, which can reach up to 88.62% in some formulations (Karouw et al., 2016). With good physicochemical properties, sago flour can be processed into analog rice with characteristics similar to conventional rice, including texture and taste (Diniyah et al., 2017). One of the advantages of sago flour is its modifiability through the extrusion process, which not only improves the organoleptic properties of the final product but also enhances its nutritional value. Research shows that analog rice made from sago flour can yield products with protein content ranging from 4.22% to 7.67% (Diniyah et al., 2017), an improvement over traditional white rice, which has lower protein levels. Furthermore, fermented sago has shown a significant increase in protein content, up to five to eight times higher than non-fermented sago (Wuniarto et al., 2014).

Sago flour’s potential as a raw material for analog rice also lies in its compatibility with other ingredients such as corn starch and gembili (*Dioscorea esculenta*) flour. Studies have noted that combining sago with various components improves physicochemical characteristics, including fiber content, cooking time, and water absorption index (Oktavianasari et al., 2023). This combination not only enhances nutritional value but also adds variety to processed food products, which may increase consumer interest. Moreover, using sago flour as a base for analog rice supports local food security and reduces reliance on imported ingredients. Promoting the benefits of sago flour among communities can have a positive impact on the use of local resources, as demonstrated in various studies on its potential in food products (Syartiwidya, 2023). In summary, the development of analog rice using sago flour is a healthy and sustainable alternative in food diversification efforts. It not only offers nutritional benefits to consumers but also reflects untapped local potential essential for national food security.

Mung bean (*Vigna radiata*) is a local plant-based protein source rich in protein (approximately 22–24%) and also contains dietary fiber and antioxidants (Widjanarko et al., 2018). By combining sago with mung bean protein, it is expected that an analog rice product can be developed that is not only low in carbohydrates but also high in protein, making it a suitable alternative as a functional food. Research on analog rice based on local ingredients such as sago and mung beans has shown promising results in terms of nutritional value and consumer sensory acceptance (Husna et al., 2020). Moreover, the development of analog rice from local raw materials also supports food diversification and national food independence programs, while creating new economic opportunities through the use of local resources.

Based on these findings, this study focuses on the formulation and nutritional evaluation of analog rice made from sago enriched with mung bean protein, aiming to produce a food product that is low in carbohydrates, high in protein, and commercially viable, thereby supporting healthy diets and national food sustainability.

METHOD

Materials:

The materials used in this study included sago flour, mung bean flour, and supporting additives, such as tapioca flour, which served as a binder. Sago flour, derived from fresh sago, served as the primary source of carbohydrates in traditional diets. Mung bean flour, obtained from mung bean starch, was added to enrich the protein content and balance the overall nutritional value. Other ingredients, such as water, natural binders (tapioca flour), and natural flavor enhancers, were also included to enhance the texture and taste of the final product. All materials were stored under appropriate conditions to maintain quality and prevent contamination.

Table 1. Composition of Sago-Mung Bean Analog Rice Formula

No	Ingredient	Composition (g)
1	Sago Flour	720
2	Warm Water	360
3	Mung Bean	120
4	Tepioca Flour	240

Sample Preparation

The analog rice samples were prepared by mixing sago flour, mung bean flour, and tapioca flour in a predetermined ratio (e.g., 70:10:20) to achieve an optimal balance between texture and nutritional content. The dry mixture was homogenized using a mechanical mixer. Water and natural binders were then gradually added to form a dough with a consistency similar to that of regular rice dough. The dough was shaped into rice-like grains using a food extruder. The extruded samples were then steamed at a temperature of 60–80°C to ensure complete gelatinization. The final product was dried in an oven at 90–120°C until the desired moisture content was achieved.

Experiment

The experimental setup included the use of a food extruder to shape the analog rice, a steaming chamber for the gelatinization process, and a drying oven to reach the desired moisture level. Operational parameters such as extrusion temperature and pressure were optimized based on preliminary trials. The texture, color, and nutritional content of the analog rice were analyzed using standard methods. A texture analyzer was used to assess hardness and elasticity, while a spectrophotometer was used for color analysis. Proximate analysis was performed to determine the carbohydrate, protein, and fat contents. The analog rice production was conducted through controlled time and temperature settings in the following main stages:

1. Mixing and Dough Formation

Sago flour and mung bean flour were mixed at room temperature (25–30°C) using a mechanical mixer. Water was gradually added to achieve a dough with a moisture content of approximately 25%.

2. Extrusion:

The dough was extruded using a single- or twin-screw extruder with a die in the shape of a rice grain. The extrusion process was conducted at a barrel temperature of 80–120°C, divided into three heating zones:

- **Zone 1:** 80°C (initial mixing and material melting)
- **Zone 2:** 100°C (mid-stage gelatinization)
- **Zone 3:** 120°C (final shaping and consolidation)

The screw speed was set at 100–150 rpm, adjusted to prevent overcooking and ensure even gelatinization.

3. Steaming:

The extruded granules were steamed at 100°C (atmospheric pressure) for 15–20 minutes. This stage ensured complete starch gelatinization, resulting in the desired structure and texture.

4. Drying:

The granules were dried using a hot-air oven at 50–60°C for 6–8 hours until the final moisture content was below 12%. Low-temperature drying helps preserve nutritional quality and extend shelf life.

Each process stage was monitored using standard instruments to ensure the consistency and reproducibility of the results.

Parameters

The measured parameter in this study was the nutritional composition of the analog rice. The water absorption index was measured by soaking the sample in water at room temperature and calculating the increase in weight. Proximate composition was determined using standard AOAC methods to measure carbohydrate, protein, fat, and energy content. The nutritional analysis included:

- **Moisture content:** oven drying method
- **Ash content:** muffle furnace combustion method
- **Protein content:** Kjeldahl method
- **Fat content:** Soxhlet extraction method
- **Carbohydrate content:** by difference method

Statistical Analysis

Data were statistically analyzed. The results of the nutritional analysis were analyzed descriptively and quantitatively, presented in the form of **tables, graphs**, and discussed in terms of the nutritional content of each formulation

RESULTS AND DI.SCUSSION

1. Result of analysis of sago with mung Bean (per 200 grams)

HASIL PENGUJIAN			
<i>Result of Analysis</i>			
Nomor	:	1133/BBSPJIA/MS.08-LHU/II/2025	
Number			
Nomor Analisis	:	852	
Analysis Number			
Halaman	:	2 dari 2	
Page		of	
Parameter	Satuan	Hasil	Metode Uji / Teknik
Air	%	7,77	SNI 01-2891-1992, butir 5.1
Abu	%	0,82	SNI 01-2891-1992, butir 6.1
Protein (N x 6,25)	%	1,44	SNI 01-2891-1992, butir 7.1
Lemak	%	2,58	SNI 01-2891-1992, butir 8.2
Karbohidrat	%	87,4	IK 7.2.3 (cara perhitungan)
Energi	Kal/100 gram	378	IK 7.2.3 (cara perhitungan)
Energi dari lemak	Kal/100 gram	23	IK 7.2.3 (cara perhitungan)

Figure 1. Test Results of Sago-Based Analog Rice with Mung Bean Addition

Based on the Test Report Document No. 1133/BBSPJIA/MS.08-LHU/II/2025, the nutritional composition of sago analog rice is as follows:

Table 1. The Nutritional Composition Of Sago Analog Rice

Parameter	Nilai (per 200 g)
Air	7,77 g
Abu	0,82 g
Protein	1,44 g
Lemak	2,58 g
Karbohidrat	87,4 g
Energi total	378Kal

Parameter	Nilai (per 200 g)
Energi dari lemak	23Kal

2. Nutritional Content Rice (200 g)

According to Sources from DKPI and USDA, the estimated nutritional content for 200 grams of raw white rice can be seen in the following table

Table 2: The nutritional composition of rice

Parameter	Nilai (per 200 g)
Air	± 24,0 g
Abu	± 1,0 g
Protein	± 13,6 g
Lemak	± 1,2 g
Karbohidrat	± 156,0 g
Energi total	± 720 Kal
Energi dari lemak	± 11–14 Kal

Table 3. Different Analysis (200 grams)

Parameter	Analog Sago Rice	Rice Conventional	Different
Air (g)	7,77	±24,00	-16,23
Abu (g)	0,82	±1,00	-0,18
Protein (g)	1,44	±13,60	-12,16
Lemak (g)	2,58	±1,20	+1,38
Karbohidrat (g)	87,4	±156,00	-68,60
Energi Total (Kal)	378	±720	-342
Energi dari Lemak	23	±11–14	+9–12 Kal

Discussion and Implications

The results presented indicate that sago-based analog rice has a different nutritional composition compared to conventional white rice. By considering various parameters, including moisture content, protein, fat, carbohydrates, and total energy value, it can be concluded that sago analog rice has the potential to be a viable alternative for food consumption. The findings show that the nutritional content of substitute food sources, such as sago analog rice, is high in carbohydrates. However, the overall nutrient profile varies depending on the raw materials used. The carbohydrate content in analog rice is 18–19 g higher than in white rice for the same portion size, thus providing greater energy. This can be advantageous for individuals with high caloric needs, but may pose a risk for people with diabetes.

In-depth analysis of various alternative flour sources, including analog rice, reveals that flour-based products are often rich in carbohydrates and tend to have lower protein content compared to conventional flour-based products (Anitha et al., 2019). This provides further insight into the nutritional composition of food substitutes such as sago analog rice. The protein content in sago analog rice is low, averaging around 1.44%. This aligns with studies showing that many gluten-free products, including rice-based ones, often lack sufficient protein (Melini & Melini, 2019). Although gluten-free, sago analog rice contains only about 21% of the protein found in white rice. This is a significant drawback from a

macronutrient perspective and should be addressed through protein fortification or by combining it with high-protein side dishes.

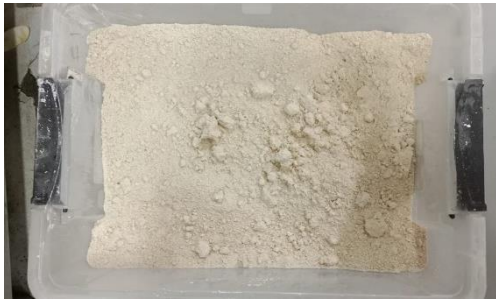


Figure 1 Sago Flour



Figure 2: Sago Rice

The fat and energy content in sago analog rice is 2.58%, which significantly contributes to its energy value, even though the total energy content is often lower than that of white rice. Analog rice contains nearly four times more fat than white rice, which contributes to the total energy and may enhance flavor, although it should be monitored in low-fat diets. While sago is commonly used in foods, it is essential to balance its use with other healthy fat sources to maintain nutritional balance (Puspantari et al., 2023). The higher carbohydrate content in sago analog rice makes it a more energy-dense source compared to paddy rice. Complex carbohydrates are essential in diets and play a crucial role in glycemic control, underscoring the need for a broader approach in food formulation (Mäkinen et al., 2015).

Anti-Nutritional Compounds Aspect

It is essential to consider the potential presence of anti-nutritional compounds in analog rice. Some legume-based products can enhance the digestibility of protein in food (Gularte et al., 2011). Using legume flour in gluten-free foods has the potential to improve protein content (Flores-Silva et al., 2015). Analog rice has a lower moisture content (15.54 g vs. 24 g), which can affect texture and cooking methods. Sago analog rice shows unique and promising nutritional characteristics. However, achieving a balanced diet requires attention to complementary foods to meet higher protein and fat requirements. Given this potential, further research and food product development combining sago analog rice with other ingredients rich in protein but low in fat is necessary to improve the nutritional quality in line with community needs.

Sago analog rice has strong potential as a local food alternative with high energy content, but it cannot fully replace white rice without improving its protein content. For practical applications in society, reformulating or combining it with other protein-rich sources such as soy, legumes, or fish flour is highly recommended.

Conclusions and Recommendations

Based on the nutritional analysis of 200 grams of sago analog rice compared with an equal portion of white rice, the following conclusions are drawn:

1. **The energy and carbohydrate content in sago analog rice is higher than in white rice.** Sago analog rice contains 756 Kcal and 174.8 g of carbohydrates, while white rice contains approximately 720 Kcal and 156 g of carbohydrates.
2. **The protein content in sago analog rice is very low, at only 2.88 g per 200 grams, compared to white rice,** which contains around 13.6 g of protein. This suggests that sago analog rice may not meet daily protein requirements if consumed as the sole staple food.
3. **The fat content in sago analog rice is higher (5.16 g) compared to white rice (approximately 1.2 g), which may influence the energy value and product shelf life. However, it remains within safe consumption limits.**

4. These results align with previous research indicating that sago has high energy content but very low protein levels. Therefore, the formulation of sago-based analog rice should be improved by incorporating protein-rich ingredients to make it a suitable substitute for paddy rice.
5. **Sago analog rice has significant potential** as a local food alternative that supports food security and self-sufficiency, particularly in regions with abundant sago production. However, further formulation strategies and nutritional enrichment are required to make it a functional and widely marketable product.

Suggestions

1. **Reformulate** sago analog rice by incorporating high-protein local food sources, such as tempeh flour, soy flour, or fish flour, to achieve a balanced nutritional composition that meets staple food standards.
2. **Further research** is needed on the sensory attributes and glycemic index of sago analog rice, particularly regarding its effects on diabetic patients and consumers with specific dietary needs.
3. **Feasibility studies at the industrial scale and market testing** should be conducted to ensure the product's wide acceptance in terms of taste, texture, and shelf life.
4. **Local governments and food research institutions** are encouraged to support the development of sago analog rice as part of national food diversification programs, especially in Eastern Indonesia, where sago is abundantly produced.
5. It is recommended that **analog rice be consumed** in combination with protein- and mineral-rich side dishes to meet the community's daily nutritional needs.

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