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# An Evaluation of Sago-Rice Consumption on Nutritional and Biochemical Parameters in Overweight and Obese Participants

## *Evaluasi Konsumsi Nasi Sagu terhadap Parameter Gizi dan Biokimia pada Responden dengan Berat Badan Berlebih dan Kegemukan*

**Galih Kusuma Aji[1], Bambang Hariyanto[2], Alit Pangestu[3]*, Ambar Dwi Kusumasmarawati[1], Purwa Tri Cahyana[1]**

[1]Research Center for Process Technology, National Research and Innovation Agency of Indonesia, Banten, Indonesia
[2]Food Technology Department, Sahid University, Jakarta, Indonesia
[3]Research Center for Food Technology and Processing, National Research and Innovation Agency of Indonesia, Yogyakarta, Indonesia

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****Correspondent:***
*Alit Pangestu*
*alit001@brin.go.id*

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**ABSTRACT**

**Background:** Overweight and obesity are conditions caused by overnutrition, where an individual has an excessive nutrient intake. These conditions can lead to blood glucose and lipid problems. Sago rice, rich in resistant starch and fiber, offers a potential solution to this issue.
**Objectives:** This study aimed to investigate the impact of eating sago rice over 4 weeks on the biochemical (glucose, total cholesterol, and triglyceride) and nutritional (body weight, Body Mass Index (BMI), total fat, and visceral fat contents) parameters in overweight and obese participants.
**Methods:** Each participant consumed approximately 200 g of sago rice during lunch for 4 weeks. The researchers measured the participants' body weight and height, which were then used to calculate their BMI before and after consuming the sago rice. They also performed Bioelectrical Impedance Analyses (BIA) to calculate the participants' body and visceral fat percentages before and after consumption. The participant's total cholesterol and triglycerides were also examined before and after the sago-rice consumption using the spectrophotometry method.
**Results:** After 4 weeks of sago-rice consumption, the results highlighted a significant decrease in body weight, BMI, and body fat percentage (p-value<0.05). This study demonstrated that consuming sago rice for 4 weeks could significantly decrease the participants' total cholesterol levels by approximately 18 mg/dL, from 257.33 mg/dL to 239.48 mg/dL (p-value<0.05). Conversely, the participants' triglyceride levels increased (p-value<0.05). However, blood glucose concentration was not significantly different (p-value>0.05).
**Conclusions:** Therefore, sago rice consumption can help reduce body weight, BMI, body fat percentage, and total cholesterol levels in overweight and obese individuals.

## INTRODUCTION

Overweight and obesity are major health problems in Indonesia, with a prevalence of 13.6% and 21.8% in 2018, respectively[1]. Overnutrition is closely related to people's lifestyles and diet, where they may consume an excess of nutrients[2,3]. Overweight and obesity might lead to degenerative diseases, including dyslipidemia, cardiovascular disease, schizophrenia, Diabetes Mellitus (DM), and other diseases[4,5]. Therefore, a healthy source of carbohydrates in the diet, high in resistant starch or fiber, can be one solution for overcoming overweight and obesity.

Indonesia is the second-largest producer of sago (*Metroxylon sp*)[6]. Sago is a carbohydrate source with low fat content, and its flour contains 18.31% resistant starch. It can also be modified using physical, chemical, and biological methods to obtain a higher level of resistant starch[8,9]. However, sago consumption as a staple food has a low acceptance in Indonesia due to its high viscosity[10]. Therefore, a strategy that has been implemented to increase its acceptance is the development of analog rice from sago (sago-rice), as most Indonesians consume rice[11]. Most common staple carbohydrate sources in Indonesia like rice and wheat products, such as biscuits, bakery foods, and noodles, have a higher GI compared to sago-rice. Meanwhile, sago-rice has a low Glycemic Index (GI) of 55.5 and is high in resistant starch and fiber (18.31% and 6.86%, respectively)[12]. Thus, sago-rice is a promising alternative to rice and wheat products, as it is naturally abundant in Indonesia and has been traditionally consumed as a dietary staple. These attributes also make it a healthy alternative for overweight and obese individuals to lower their body weight and maintain blood glucose levels.



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Overnutrition can lead to biochemical problems, including high blood glucose and total cholesterol levels[4]. Foods that contain resistant starch and fiber can help control and maintain blood glucose and total cholesterol levels. Previous studies have reported that foods with a low GI, high dietary fiber, and high resistant starch can help control blood glucose levels in diabetic patients. In a meta-analysis study, fiber and undigested starch have also been clinically proven to reduce blood cholesterol levels[13,14]. Moreover, a study involving sago-rice consumption in pre-diabetic individuals for 4 weeks resulted in a reduction of 13.6 mg/dL in the participants' 2-hour postprandial blood samples[15].

In addition to sago-rice's ability to maintain blood sugar levels, many studies have reported that resistant starch and dietary fiber can lower cholesterol levels. A study in which sago-rice was fed to diabetic rats showed that sago-rice could decrease total cholesterol by 47% and triglycerides by 37%[16]. A study involving pre-diabetic individuals also found that sago-rice can reduce their cholesterol and triglycerides by approximately 12 mg/dL (from 212.35 to 200.95) and 29 mg/dL (from 159.65 to 130.1), respectively[15].

Although extensive research has been conducted on obesity and nutrition, the specific impact of sago-rice on key nutritional indicators, such as BMI, body fat percentage, glucose, cholesterol, and triglyceride levels, remains underexplored. It is also vital to study obesity since it is a major global health problem linked to many degenerative diseases, such as metabolic disorders, diabetes, and cardiovascular diseases. Addressing this gap could provide insights into alternative dietary approaches that may aid in obesity management and metabolic health. Moreover, the increasing prevalence of obesity and its related health risks highlight the importance of investigating possible dietary solutions that could improve its prevention and treatment.

Sago-rice has not been thoroughly studied regarding its capacity to maintain biochemical and nutritional parameters, such as body weight, blood glucose, cholesterol, and triglycerides, in overweight and obese individuals. Therefore, this study aims to investigate the impact of consuming sago-rice for four weeks on anthropometric parameters, including body weight, BMI, and total and visceral fat percentages. Additionally, this study examined biochemical parameters, such as blood glucose, triglycerides, and total cholesterol.

## METHODS

### Research Design

This study employed the one-group pre-posttest design. The research was conducted by the Agency of Assessment and Application of Technology, Indonesia, from October to November 2018. The participants' staple food was changed from rice to sago-rice for 4 weeks, with a minimum consumption of 1 serving of sago-rice per day (200 g/day). Sago-rice was served at lunch during workdays (from Monday to Friday) or 5 days a week. Additional knowledge and insights were provided to the participants before the study to help them manage their diet during the study. A nutrition consultation session was also provided to explain and describe a balanced nutritional diet to the participants. During this study, all participants were advised to practice a balanced diet of 2000 kcal. They were advised to apply the Food Exchange List (DBMP) principle, which recommends two servings of carbohydrates, two servings of protein, and two servings of fat per meal. The participants were also encouraged to perform physical activities for a minimum of 30 minutes at least once per week. This research lasted for 4 weeks. The researchers measured each participant's weight and height, as well as their subcutaneous fat (total and visceral), blood glucose, total cholesterol, and triglyceride levels, before consuming sago-rice. After 4 weeks of treatment, all parameters were measured again. The summary of these activities is shown in Figure 1. Ethical approval was obtained from the Faculty of Medicine Ethics Committee, Universitas Indonesia, Indonesia (1189/UN.2F1/ETIK/2018) on 12 November 2018. In addition, all participants signed the informed consent form.

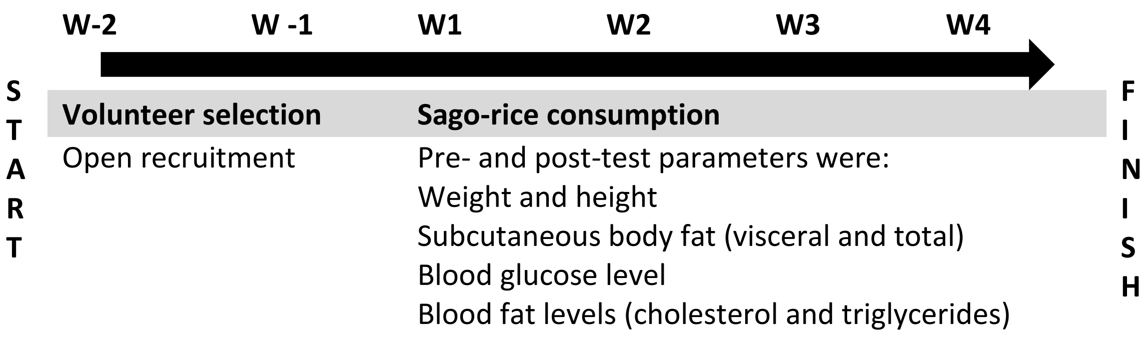


**Figure 1.** The study's research flow

### Participants

The minimum sample size was calculated with 80% power and a significance level of 0.05. This study also assumed that cholesterol levels would be lowered by 10 mg/dL, with a standard deviation of 20 units, as shown in the formula below[15]. Additionally, 20% of the participants' losses were taken into account in the calculation to determine the total number of participants. Thus, the minimum sample for this study was 40 participants.

$$N = \frac{(Z1 + Z2)^2 \ x \ S^2}{d^2}$$



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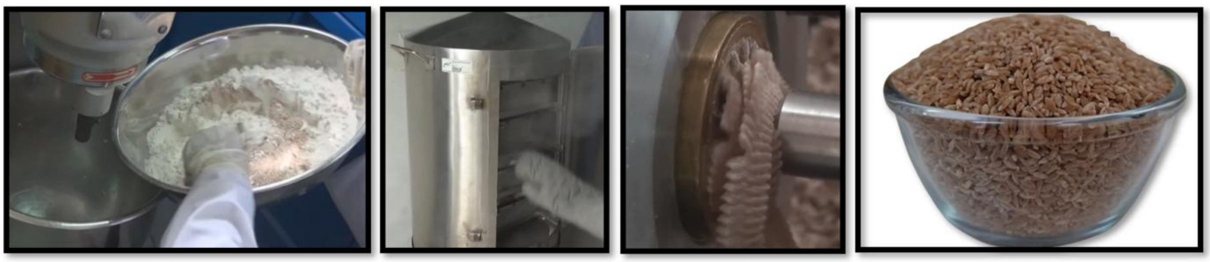
Note:
N=Total Respondent
$Z_1$=% Confidence Level of 95%, and α=0.05 (1.96)
$Z_2$=Power of 80% (0.84)
S=Population Standard Deviation
d=Detected Difference Wanted

The participants who met the inclusion criteria were 1) men or women aged 21-65 years, 2) has a body mass index >23 kg/m$^2$, 3) willing to consume sago-rice at least once per day for 4 weeks, 4) not be pregnant, 5) do not smoke, 6) do not consume alcoholic drinks, and 7) have DM. All participants signed the informed consent form before the start of the study. The participants who were not present at one of the examinations and categorized as outlier data were excluded from this study.

**Sago-Rice**

Sago-rice was prepared by mixing sago starch (70%) and brown rice flour (30%)[12]. Firstly, the composite flour (sago starch and brown rice flour), carrageenan, and Glycerin Mono Stearate (GMS) were added with water, homogenized for 5 minutes in a mixer, and steamed for 15 minutes. Next, the steamed mixture was added into an extruder with a two-extrusion process. Once the flour resembled rice, the sago-rice was dried in a cabinet dryer at 50°C for 12 hours. Every 100 g of sago-rice contains 380.14 kcal (2.14% energy, 3.16% fat, 87.06% protein, 6.86% carbohydrate, 11.18% dietary fiber, 4.5% resistant starch, and 55.5% GI).


(a) (b) (c) (d)
**Figure 2.** Sago-rice preparation process (d), including mixing (a), steaming (b), and extrusion (c)

**Nutritional Measurement**

The researchers performed two anthropometric examinations, one in week 0 and the other in week 4, except for height, which was measured only once. Body weight was measured using a digital scale with an accuracy of 0.1 kg (OMRON HBF 375 Karada Scan, China). Height was measured at week 0 using a microtoise with an accuracy of 0.1 cm (OneMed Stature Meter, Indonesia). The participants' BMIs were calculated using a formula that applied criteria from the World Health Organization for the Western Pacific region[17]. An individual was categorized as overweight if their BMI was between 23.00 and 24.99. Obesity was defined as an individual with a BMI over or equal to 25[18]. Body fat percentages were measured, focusing on total and visceral fat, using a BIA device (Omron HBF 375 Karada Scan, China)[19].

**Blood Sample Analysis**

Phlebotomists drew approximately 3 ml of the participants' blood from the median cubital vein before and after the intervention. Next, the sample was centrifuged at 2000 rpm for 10 minutes to obtain the blood serum. Then, the researchers measured the blood glucose level, total cholesterol, and triglycerides using a reagent kit from Dyasis, Germany (Glucose GOD FS 10, Cholesterol FS 10, and triglycerides FS 10, respectively). The blood analysis process was conducted in Balai Layanan Kesehatan PUSPIPTEK. In this community health center, the researchers used a spectrophotometer at 500 nm to determine the sample's glucose, cholesterol, and triglyceride levels.

**Data Analysis**

The statistical analysis was performed using the Past 4.11 Software[20] after cleaning the outlier data to obtain the data distribution for each variable (the Z value is more significant than +2.5 and less than -2.5). A different test (paired t-test) was conducted to determine the difference between blood glucose and cholesterol levels before and after consuming sago-rice. The researchers also conducted the Wilcoxon test, a non-parametric test, to analyze the difference in the participants' body weight, BMI, body fat percentage, and triglyceride levels between and after the intervention. The significance level was 95% (α=0.05).

## RESULTS AND DISCUSSIONS

**Participants**

Initially, ninety participants were recruited and signed the informed consent form. Fourteen subjects were excluded because four had DM, and ten had a normal nutritional status. Fifty-four subjects completed the study, and when the data was cleaned, 12 subjects were excluded due to outlier data. Lastly, 42 subjects (13 men and 29 women) with an average age of 40.31±10.81 were used in the statistical analysis (Table 1 and Figure 3). Most participants (93%, or 39 people) had at least a bachelor's degree. This finding may be attributed to the study being conducted in a research center (Table 1).



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**Table 1.** Distribution of participants' educational background, gender, and their average age

| Parameters | Mean±SD | N (%) |
|---|---|---|
| **Age** | 40.31±10.81 | |
| **Education** | | |
| <Undergraduate | | 3 (7.1) |
| ≥Undergraduate | | 39 (92.9) |
| **Sex** | | |
| Male | | 13 (31) |
| Female | | 29 (69) |

SD=Standard Deviation; N=Frequency

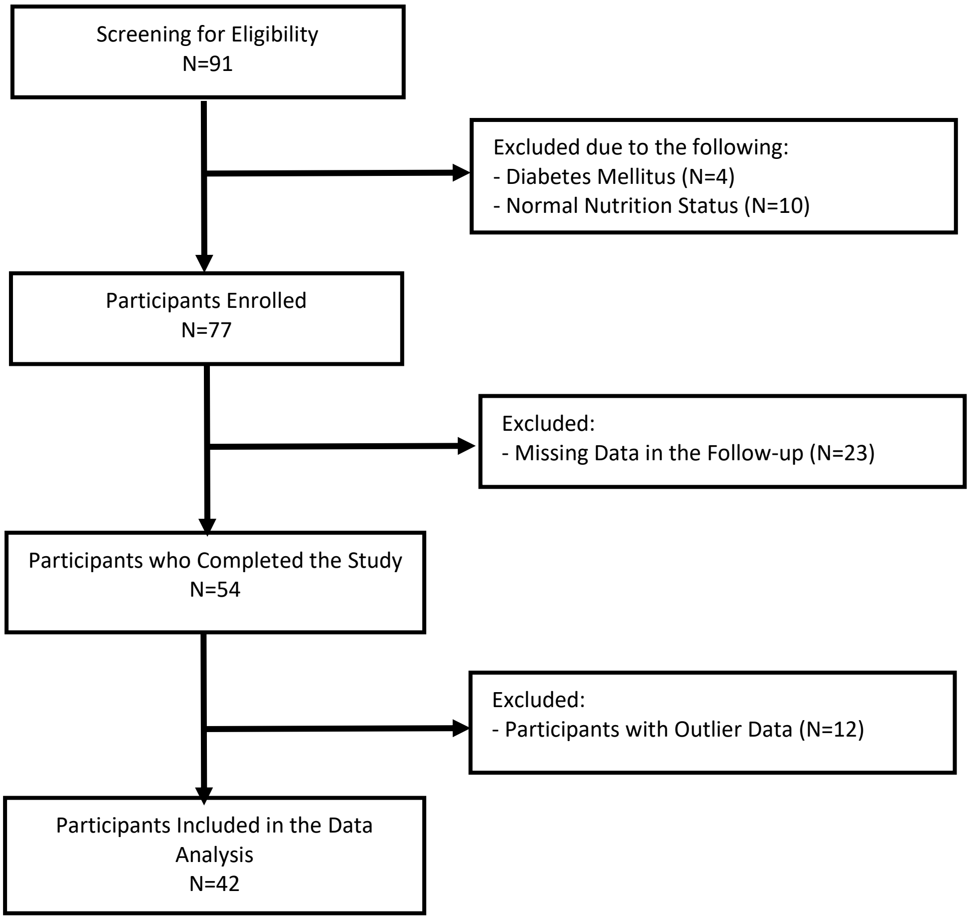


**Figure 3.** Flowchart of the progression of the number of participants in the study

**Nutritional Parameters**

The nutritional parameters observed in this study were body weight, BMI, and body fat percentage (visceral and total fat) (Figure 4). Body weight is a dynamic anthropometric parameter that is influenced by diet and lifestyle[21]. The average body weight before the study was 67.47±10.24 kg (Table 2). After four weeks of treatment, the average body weight became 67.04±10.21 kg (Table 2), indicating a significant weight loss of 0.43 kg (p-value<0.05) before and after consuming sago-rice (Figure 4).

This study's findings align with a similar study on fiber and weight loss, which observed that participants experienced weight loss within a range of 0.3 kg to 2.5 kg with regulated fiber consumption and 0 kg to 5.8 kg with ad libitum fiber consumption[22]. Sago-rice is rich in fiber and resistant starch, which presumably plays a role in the reduction in this study. Although this study did not observe the participants' food intake and consumption, it could be hypothesized that their food intake is lower than without the intervention. Studies have shown that consuming foods high in fiber and undigested starch could reduce food intake at meal times and overall consumption within 24 hours[23] due to several mechanisms[14,22,24,25]. The first mechanism is that fiber and undigested starch provide no caloric intake since the digestive system does not metabolize them. The second potential reason is that consuming high-fiber food allows



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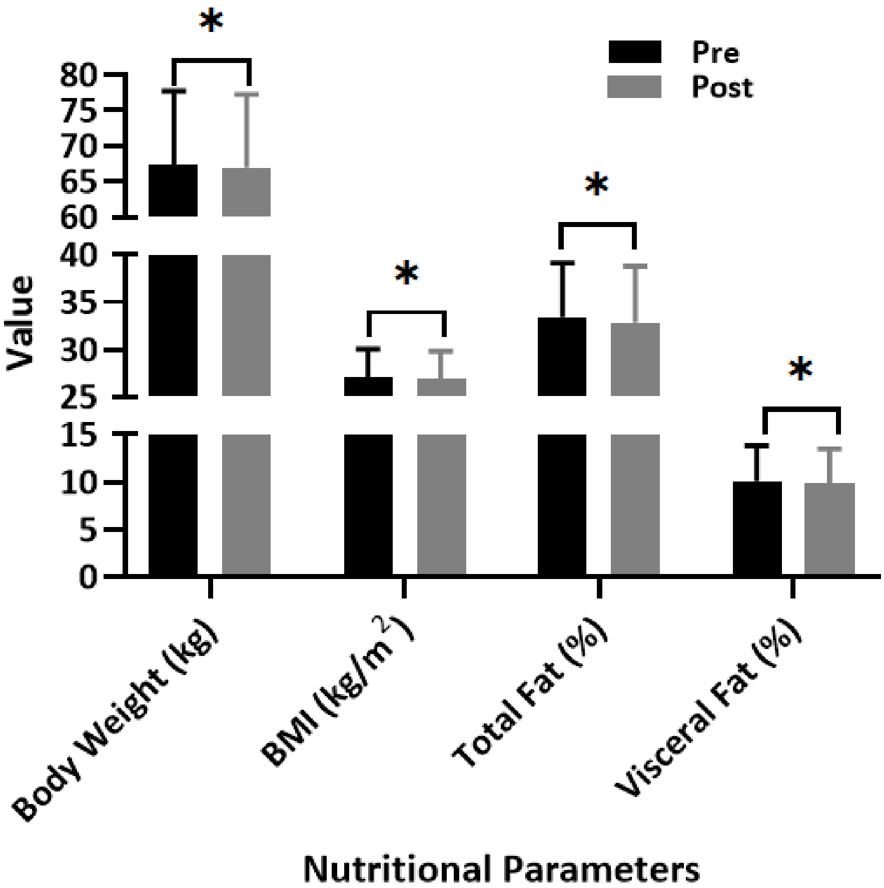
for a longer stomach transit time, which slows down hunger and prolongs satiety. Lastly, the mechanism lowers the digestive tract's capacity to absorb energy[14,22,24,25].




*) Significant difference at p-value<0.05 using the Wilcoxon test
**Figure 4.** Weight, BMI, total and visceral fat values before and after consuming sago-rice for 4 weeks

**Table 2.** Descriptive analysis for body weight, BMI, total and visceral fat, blood glucose, total cholesterol, and triglycerides

| Parameter | Mean | | Standard Deviation | | Minimum | | Maximum | |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Body Weight (kg) | 67.47 | 67.04 | 10.24 | 10.21 | 51.3 | 52 | 91 | 90.5 |
| Body Mass Index ($kg/m^2$) | 27.06 | 26.85 | 2.98 | 2.99 | 23.2 | 23 | 34.6 | 34.2 |
| Total Fat (%) | 33.42 | 32.88 | 5.7 | 5.91 | 21.3 | 20.5 | 41.7 | 41.4 |
| Visceral Fat (%) | 10.1 | 9.86 | 3.75 | 3.61 | 4 | 4.5 | 19.5 | 19 |
| Blood Glucose (mg/dL) | 93.36 | 92.05 | 11.9 | 9.34 | 70 | 67 | 113 | 107 |
| Total Cholesterol (mg/dL) | 257.33 | 239.48 | 30.9 | 34.6 | 202 | 180 | 325 | 303 |
| Triglycerides (mg/dL) | 84.1 | 111.6 | 22.81 | 26.31 | 44 | 70 | 144 | 181 |

Weight loss also correlates with BMI reduction[26]. Weight is a factor in calculating BMI, regardless of height. This study found a decrease in BMI of approximately 0.21 $kg/m^2$, which declined from 27.06 $kg/m^2$ to 26.85 $kg/m^2$ after 4 weeks of treatment, corresponding to a change in body weight (Figure 4). Moreover, a meta-analysis study found that soluble fiber could reduce BMI by −0.84 $kg/m^2$ [27]. Another study also found that consuming over 25 g of resistant starch per day for one year resulted in a decrease of the participants' BMI levels by 4.2%[28].

Table 2 shows that the percentages of total and visceral fat decreased from 33.42±5.7% to 32.88±5.91% and from 10.1±3.75% to 9.86±3.61%, respectively. A significant reduction (p-value<0.05) was observed in both



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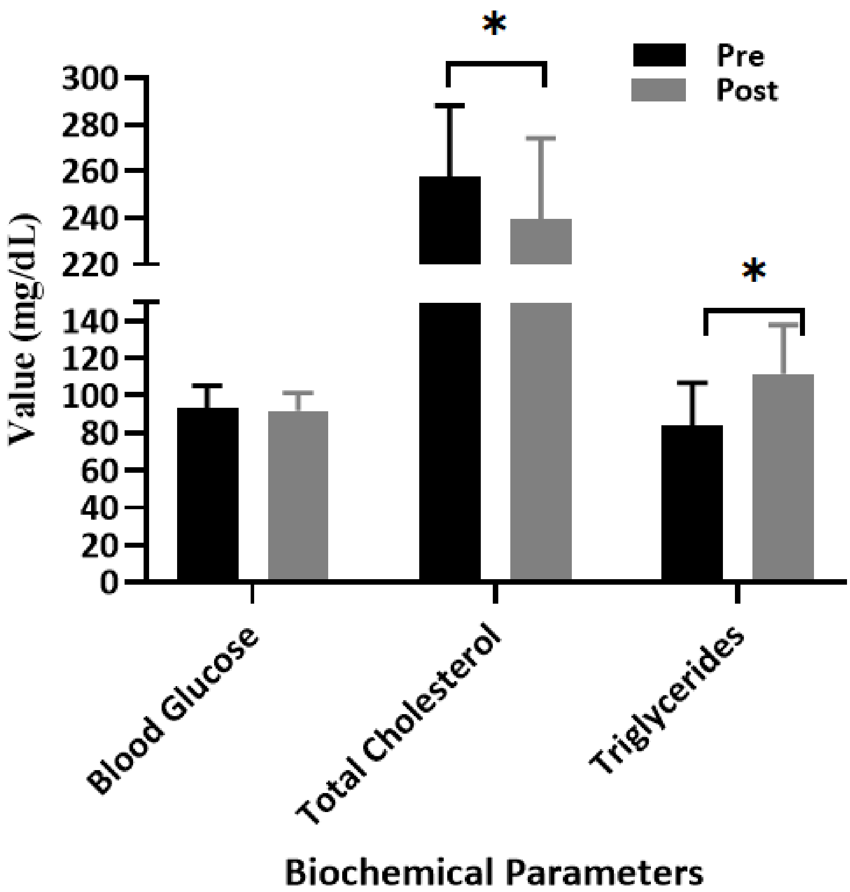
types of fat, as illustrated in Figure 4. Reducing body weight can lead to a decrease in body fat. This result suggests that using sago-rice as a replacement for rice can significantly reduce visceral and total fat levels (-0.24% and -0.54%, respectively). This reduction in fat levels may be due to the intake of sago-rice, which contains a high amount of fiber and resistant starch, which can increase fat oxidation[29,30]. Previous studies have shown that fat oxidation is stimulated by low energy intake and activating hormonal pathways[31]. This study's findings align with previous studies, as they demonstrate that reducing energy intake by using sago-rice led to a decrease in visceral fat after four weeks of treatment.

**Biochemical Parameters**

The blood biochemical parameters observed in this study were glucose, cholesterol, and triglycerides. The participants' average blood glucose levels before and after the study were 93.36±11.9 mg/dL and 92.05±9.34 mg/dL, respectively (Table 2). However, this difference was not statistically significant (p-value > 0.05) (Figure 5). In contrast, the blood cholesterol parameter showed a considerable decrease (p-value<0.05) of around 18 mg/dL, from 257.33±30.9 to 239.48±34.66 mg/dL, as demonstrated in Table 2 and Figure 5.




A paired T-test was used to analyze the participants' glucose and cholesterol levels, and the Wilcoxon was used to analyze triglyceride levels. *) Significant difference at p-value<0.05

**Figure 5.** Difference in test results (Paired T-test) between biochemical parameters (glucose, total cholesterol, and triglycerides) before and after consuming sago-rice for 4 weeks

Dietary fiber and resistant starch may have cholesterol-lowering benefits. These two compounds may lower cholesterol by increasing the viscosity of intestinal contents, thereby inhibiting the reabsorption of cholesterol. This mechanism will cause an increase in the unloading of LDL in the liver, serving as a cholesterol source in the gallbladder, which in turn will lower blood cholesterol levels[24,25,32-34]. Several studies have shown that soluble dietary fiber is effective in lowering cholesterol levels[35-39]. The Food and Drug Administration (FDA) in the United States claimed that 0.75 or 1.7 g per serving of dietary fiber from beta-glucan (oat and psyllium husk) can reduce the risk of heart disease[40]. In addition, a meta-analysis study by Yuan et al. (2018) reported that resistant starch has been clinically proven to reduce blood cholesterol when consumed for more than 4 weeks[13]. Thus, both compounds (resistant starch and dietary fiber) contributed to the decline in the participants' total cholesterol levels in this study.

Furthermore, dietary fiber and resistant starch have the potential to reduce triglyceride levels, which are fatty acids that bind in the small intestine[41]. A study on teenagers found that eating high-fiber cereal with a breakfast high in fat significantly reduced their post-meal



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rise in triglycerides by 50%[42]. In this study, triglyceride levels remained within the normal range (< 150 mg/dL)[43], despite an increase in blood triglyceride levels after 4 weeks of treatment. The participants' triglyceride levels increased from 84.1±22.81 mg/dL to 111.6±26.31 mg/dL (p-value<0.01) (Figure 5). However, several studies have shown contradictory results, with some indicating a decrease and others an increase. Several meta-analysis studies also stated that dietary fiber and resistant starch do not affect blood triglyceride levels[22,44]. A meta-analysis of dietary fiber in 67 controlled clinical trials also yielded similar results, showing that soluble fiber did not affect the decrease in triglycerides (1.76±0.64 mg/dL)[44]. Moreover, the most recent meta-analysis study on this topic, published in 2018, indicated that the triglyceride level results were not significantly different before and after the intervention (−7.50 mg/dL; 95% CI, −16.93 to 1.92 mg/dL, analysis of articles on resistant starches up to September 2017)[13].

This research proves that local food containing sago might help maintain body weight and cholesterol levels. However, a limitation of this study is that the participants' food consumption and physical activity were not examined. This limitation may decrease the validity of the research findings, as data plays a crucial role in energy metabolism and overall health, which could influence the study's results. Addressing these limitations in future research could enhance the validity of the findings and facilitate a more comprehensive understanding of the results.

## CONCLUSIONS

The results of this study indicate that substituting rice with sago-rice for 4 weeks can significantly reduce body weight, BMI, total fat percentage, and blood cholesterol levels of overweight and obese individuals. In addition, the finding highlighted that sago-rice can lower cholesterol levels by 18 mg/dL. Therefore, sago-rice may be considered an alternative to rice that offers health benefits, especially for overweight and obese individuals.

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## CONFLICT OF INTEREST AND FUNDING DISCLOSURE

All authors have no conflict of interest in this article. The authors supplied funding for this research.

## AUTHOR CONTRIBUTIONS

GKA: conceptualization, investigation, methodology, writing original draft, writing review and editing; BH: conceptualization, methodology, supervising, writing review and editing; AP: methodology; investigation, formal analysis, writing review and editing; PTC: formal analysis, resources; ADK: formal analysis, writing review and editing.

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