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Glycemic Index of Rice by Several Processing Methods

Indeks Glikemik Nasi Putih dengan Beberapa Cara Pengolahan

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ABSTRACT

Background: In diabetes mellitus patients, one of the efforts to control normal blood glucose levels is to eat low glycemic index foods. Rice is an Indonesian staple food that contains carbohydrates. Several methods of processing could affect the glycemic index of rice.
Objectives: To analyze the glycemic index of rice processed by several methods.
Methods: The design used was quasi-experimental. A total of ten people with criteria of healthy, aged 19-29 years, having normal body mass index and blood glucose levels were used in this study. Subjects were given five treatments. Treatment: 1) was given glucose as a reference, 2) was given rice that was traditionally processed and just cooked, 3) was given rice that was traditionally processed and had been stored at room temperature (25°C) for 12 hours, 4) was given rice that was electronically processed and just cooked, and 5) was given rice that was processed in a modern way and had been stored for 12 hours in magic com at hot temperature. Among the treatments, there was a gap of 7 days.
Results: Traditionally processed rice has a glycemic index of 21.6, increasing to 24.7 after being stored at room temperature for 12 hours. Meanwhile, processed electronic rice has a glycemic index of 22.9 and increases to 36,4 after being stored in a rice cooker (hot temperature) for 12 hours.
Conclusions: The four rice groups processed by various methods had low glycemic index values. Rice stored for 12 hours had a higher glycemic index value than freshly cooked rice.

INTRODUCTION

Diabetes mellitus (DM) is a disease caused by impaired insulin secretion or low insulin concentration in the blood characterized by high blood glucose concentrations. Insulin is a hormone produced by pancreatic beta cells and plays a role in moving blood glucose into cells as the body's energy stores[1]. Based on Indonesian Basic Health Research (Riskesdas) 2018, the prevalence of diabetes mellitus in Indonesia based on a doctor's diagnosis is 2%, and the prevalence, according to blood glucose results, is 8.5%. This figure has increased compared to 2013[2]. In 2021, Indonesia will be ranked 7th among the ten countries in the world with the highest number of people with diabetes mellitus, which is 10.7 million. This figure is an increase of 167% compared to the number of people with diabetes in 2011, which reached 7.729 million[3].

Normal fasting blood glucose is 70-99 mg/dL. A person is diagnosed with diabetes if the fasting blood glucose is 126 mg/dL, while pre-diabetic is when the blood glucose level is 100-125 mg/dL[4]. People with diabetes need to control normal blood glucose levels to reduce symptoms and complications of the disease. One effort that can be made is to adjust the diet pattern by paying attention to the type of food and its glycemic index. The glycemic index (GI) of food can affect blood glucose levels. The results of previous studies on type II DM patients stated a significant positive relationship between consuming foods with a high glycemic index value and blood glucose levels[5]. Consumption of foods with a low glycemic index value will slow the rate of glucose absorption into the blood so that it can control glucose levels in the blood. This situation can improve or increase insulin sensitivity and reduce the risk of complications in patients with type 2 diabetes mellitus[1].

Rice is the Indonesian people's staple food, which comes from rice processed by boiling and cooking. Almost everyone in Indonesia consumes rice every day. The Central Statistics Agency (BPS) report showed that national rice consumption reached 28.69 million tons in 2019. It was recorded that households contributed 72% of the total national rice consumption of 20.68 million tons, around 77.5 kg per capita per year[6]. Some types of rice are white rice, brown rice, and black rice. White rice is fluffier because it contains less fiber than brown rice and black rice. This finding is what makes white rice more preferred by the public[7]. As a source of carbohydrates, every 100 grams of white rice contains 175 kcal of energy, 40 grams of carbohydrates, and 4 grams of protein[8]. The main carbohydrate content of rice is glucose which is

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absorbed into the blood as the body's primary energy source[9]. Glucose levels in foodstuffs determine the value of the glycemic index, which affects fluctuations in blood glucose levels. The glycemic index is a score or food-grade value based on the speed at which glucose is absorbed into the blood so that the type and amount of food consumed can determine the response to blood glucose levels[10]. The processing and storage of rice cause a change in the glucose content so that the GI value also changes[11].

With lifestyle changes and supported by technological developments, Indonesian people today prefer practical food processing methods. Rice processing in a modern way using a rice cooker is in great demand because, in addition to cooking rice into rice automatically, it can keep cooked rice warm before consumption. Modern rice processing has different methods and principles from traditional rice processing. Traditionally, rice is processed by boiled rice (*Diaron*) and then steamed (cooked). After cooking, the rice is stored in a container and held at room temperature. Meanwhile, modern processing is that rice is added to water and then heated using a magic com until it is cooked and still left in a magic com at a warm temperature. The existence of differences in the processing of rice can affect the glucose levels in the rice produced, which is expected to have an alternative rice processing that can produce rice with a low glycemic index to control blood glucose levels.

Dewi's (2013) research on the post-prandial blood glucose response showed that the group that consumed freshly cooked white rice had a higher blood glucose response than the group that consumed white rice yesterday, but the two groups did not show a significant difference[12]. However, examining carbohydrates in white rice and making rice, it was found that the carbohydrate content of *aking* rice (8.31%) was lower than non-*aking* rice (10.72%)[13]. Based on this background, research on analyzing the glycemic index value in white rice obtained by several processing methods must be done.

METHODS

This study used a quasi-experimental design with stages of rice processing research and glycemic index analysis. Rice processing research and glycemic index analysis were conducted at the Food Laboratory, Ngudi Waluyo University, in July 2019. This study used human subjects as respondents for the glycemic index analysis and met the ethical feasibility of research (Ethical Clearance) based on the Health Research Ethics Commission (KEPK) Universitas Negeri Semarang number 241/KEPK/EC/2019.

Rice Processing

Tools used for rice processing include pots, pans, rice cookers, food scales, measuring cups, food thermometers, and room thermometers. The ingredients used are white rice varieties IR 64 brand "Strawberry." The rice used is the type of IR-64 rice widely consumed by the public. A total of 100 grams of rice from each type of processing was analyzed for glucose levels.

In this study, four types of rice were processed in different ways. Nasi A is rice that is traditionally prepared and only cooked when eaten. Rice B is traditionally prepared and stored at room temperature for 12 hours when eaten. Nasi C is rice that is processed in a modern way and is only cooked when eaten. Nasi D is rice processed modernly and stored for 12 hours in a magic com at a warm temperature when eaten.

Traditionally, rice is processed by boiling (*Mengaron*) 100 g of washed rice in 164 ml of water for 10 minutes, or until the water is absorbed, then the iron rice is steamed for 25 minutes. Modern rice processing methods use magic com tools. The trick is to wash the rice first, then put the rice into a magic com pot and add water in a ratio of 100 grams of rice: 164 ml of water. Then Magic com is closed and activated by pressing the cooking button. The rice is cooked if the magic com indicator light changes to the "warm" sign. After that, let it sit for 15 minutes, then the lid on the magic com can be opened, and the rice is stirred evenly.

Glycemic Index (GI) Analysis

Measurement of blood glucose levels using finger-prick capillary blood samples method. The tools used are a digital blood glucose meter with the "Auto Check" brand, glucose test strips, lancet needles, and alcohol swabs. While the ingredients needed are pure glucose powder, type A rice, type B, type C, and type D. The amount of pure glucose and rice are given to each treatment, and each subject is 50 grams.

The GI analysis involved ten research subjects with criteria aged 19-29 years, healthy, and had a body mass index and normal blood glucose levels. Research subjects were given five treatments. Treatment 1 was given pure glucose as a reference. Treatment two was given type A rice, treatment three was given type B rice, treatment four was given type C rice, and treatment five was given type D rice. Between treatments was given a 7-day gap. Blood glucose measurements were carried out five times in each treatment, namely fasting glucose (before treatment) and glucose after being treated at the 30th minute, 60th minute, 90th minute, and 120th minute.

After carrying out a series of measurements of blood glucose levels on the subject, the blood glucose level data is inputted into the Microsoft Excel software. The calculation of the GI value uses the AUC (Area Under Curve) calculation formula. The GI value of white rice can be determined by comparing the AUC value of blood glucose after giving the rice sample with the AUC value of standard glucose, which has an IG value of 100. The AUC area determines the area under the blood glucose response graph curve. The most frequently used method to calculate AUC's area is the trapezoidal formula (Trapezoid Method)[10].

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Glycemic Index Calculation:

$$IG = \frac{The\ area\ under\ the\ blood\ glucose\ curve\ of\ test\ food}{the\ area\ under\ the\ blood\ glucose\ curve\ of\ standard\ food} \times 100$$

$$L: \frac{(\Delta 30-0)x\ t}{2} + \frac{(\Delta 60-0)x\ t}{2} + \frac{(\Delta 60-30)x\ t}{2} + \frac{(\Delta 90-0)x\ t}{2} + \frac{(\Delta 60-90)xt}{2} + \frac{(\Delta 120-0)x\ t}{2} + \frac{(\Delta 90-120)xt}{2}$$

Note:
L = Under the curve
t = Time
Δ = Blood glucose level

Table 1. Glycemic index

Categories	Glycemic index
Low	< 55
Middle	55 - 70
High	< 70

Source: Rimbawan dan Siagian, 2004

Data Analysis

Data analysis was done using SPSS for Windows (α=0.05). The research data has a numerical scale. The normality test of the data used the Shapiro-Wilk test and showed that the data distribution was not normal. Therefore, bivariate analysis was carried out using the Kruskal-Wallis test to examine the differences in GI values of four types of rice.

RESULTS AND DISCUSSION

Rice Weight

Rice processed and stored in four different ways has different weight results. It produces rice with different weights from 100 grams of rice processed by traditional and modern methods and storage time of 0 hours and 12 hours. The weight of rice processed by various types of processing is shown in Figure 1 and Table 2.

Traditionally processed with 0 hours of storage, Rice A had the highest weight (235 grams). Traditional rice processing is carried out in 2 stages: *Pengaronan* and steaming. *Pengaronan* is the process of boiling 100 grams of rice in 164 CCs of hot water until the water is absorbed, then steaming it in a pot filled with water. During the steaming process, the evaporation of water in the pot rises and seeps into the rice. Both processes increase the volume and weight of the rice. Rice B, which was processed using the traditional method and stored at room temperature for 12 hours, decreased in temperature and weight. This condition is because storage in a perforated plastic basket at room temperature causes the water to evaporate, making the texture drier. Rice C is processed using a modern method using Magic com with 0-hour storage, weighing 204 grams. Rice processing using Magic com only takes one process, which is 100 grams of rice, and the addition of 164 ccs of water is heated in Magic com until it is absorbed and cooked. Rice weight gain is not as significant as if it is processed traditionally. Likewise, rice D, processed by modern methods and stored in a magic com for 12 hours, remains warm (temperature 75.1°C) and weighs 176 grams. The weight of the rice experienced less because the high storage temperature caused more water evaporation.

The evaporation of rice content during storage is the same as the results of Haq's research (2010) which showed that rice stored in magic com for 72 hours experienced a decrease in water content so that the rice became drier. The longer the heating of the rice, the lower the water content of the rice. This condition happens because of the evaporation process, which causes the water in the food to come out due to a reasonably high temperature[14]. Rasulu (2012) states that the longer the heating time, the more components break down and increase the amount of bound water released[15].

Rice is a source of carbohydrates. Processed rice can increase the value of carbohydrates. Siregar (2014) stated that carbohydrates consist of simple carbohydrates (such as glucose and fructose) and complex carbohydrates consisting of polysaccharides (dextrin, glycogen, and starch). The increase in the total carbohydrate in rice is thought to be caused by the swelling of the starch granule molecules by water, which causes the starch molecular weight to increase so that the total carbohydrate content increases. However, storage time and temperature can also affect the value of carbohydrates. The longer the storage time and the higher the temperature causes the rice to be drier and lighter in weight. At the same weight, dry rice contains a higher carbohydrate value than rice with more water[16]. A similar study by Nurfiani (2018) also stated that the carbohydrate content of taro tuber flour was influenced by temperature and drying time factors. This finding is presumably because the carbohydrate will increase during the drying process with the lower water in the food[17].

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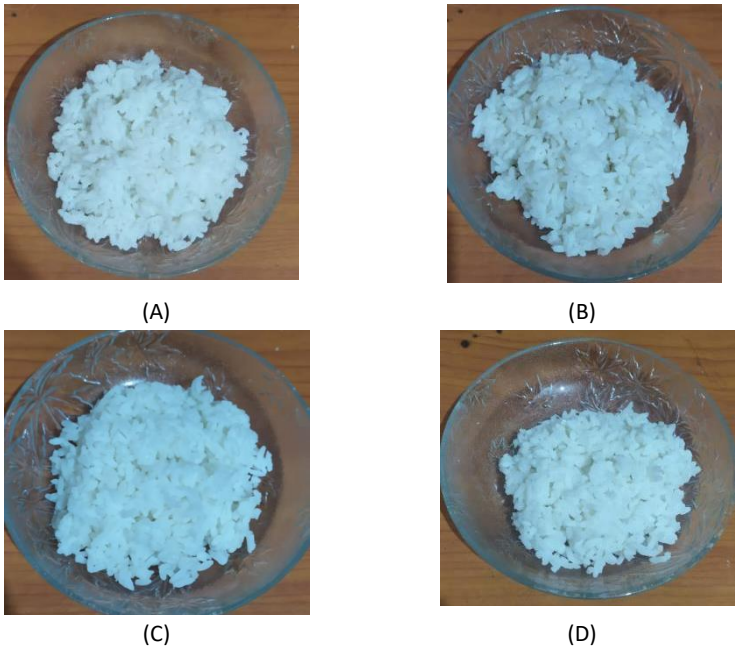

Figure 1. Rice A, rice B, rice C, rice D

Table 2. Cooked rice (*Nasi*) from 100 grams of rice

Rise processing	Temperature (^{0}C)	Mass (gram)
Rice A (traditionally method, stored for 0 hours)	96.7	235
Rice B (traditionally method, stored at room temperature for 12 hours)	20.8	228
Rice C (modern, stored 0 hours)	95.6	204
Rice D (modern, stored in the *rice cooker* for 12 hours)	75.1	176

Glycemic Index (GI)

GI analysis was determined by comparing the blood glucose response of the product treatment group (given 50 g of rice A, B, C, and D) with the blood glucose response of the reference group (given 50 g of pure glucose). Four types of rice that were processed using traditional and modern methods with a shelf life of 0 hours and 12 hours had different GI values. The results of the glycemic index analysis of the four groups of rice types are presented in Table 3.

Rice A has the lowest GI, which is 21.6. Rice A is processed by the traditional method. The water content is high, and the weight increases the most (235 g). The GI value of rice B is 24.7. This value is more significant than rice A because rice B is processed using the traditional method and has a storage period of 12 hours at room temperature, so the rice's weight decreases. Rice C, processed using modern methods, has a GI value of 22.9. This value is slightly higher than the GI value of rice A because rice C is processed only once, so the binding water content is not as much. Meanwhile, rice D, which was processed with Magic com and stored in Magic com (temperature 75.1^{0}C) for 12 hours, had the highest GI value of 36.4 because the weight of the rice was the lightest. The difference in GI values in the four types of rice is due to differences in processing and storage methods that affect the evaporation of water content. The lighter the weight, the lower on water content and the denser nutrient content, including carbohydrates. Rice A, B, C, and D had different final processing weights, and every 50 grams of rice contained different amounts of carbohydrates.

Table 3. Glycemic Index (GI) of various types of rice processing

Rice processing	GI	Categories
Rice A (traditionally method, stored for 0 hours)	21,6	low
Rice B (traditionally method, stored at room temperature for 12 hours)	24,7	low
Rice C (modern, stored 0 hours)	22,9	low
Rice D (modern, stored in the *rice cooker* for 12 hours)	36,4	low

Processing can change the structure and chemical composition of food, including carbohydrates. Therefore, different processing processes for the same type of food may cause different GI values[18]. Rice that is processed by traditional methods has a heavier weight than rice that is processed modernly. Likewise, freshly cooked rice is heavier than rice stored for 12 hours. The weight of rice is influenced by the amount of water contained. Rice with a lower weight contains a low glycemic index and high carbohydrate content. Novianti et al. (2017) proved that white rice stored in a magic com heater for 1 hour, 6 hours, 12 hours, and 18 hours

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gradually increased glucose levels[19]. The same result was also proven in the study of Haq (2010), which stated that the carbohydrate content in white rice stored in Magic com for 72 hours was higher than that of freshly cooked rice (0 hours storage). This finding is due to the evaporation of water content, causing the concentration of carbohydrates in rice to be more concentrated and the levels to increase[14].

The carbohydrate content of food can affect the blood glucose response. It is used to determine the GI value. The glycemic index value describes the effect of food consumption on fluctuations in the increase in blood glucose levels. The type and amount of carbohydrates directly affect the glycemic index, and the glycemic index can reflect the insulin response to food[10]. Several factors, including carbohydrate content, types of carbohydrates, food processing, and other components, such as fat, protein, fiber, antinutrients, and organic acids[20], influence the GI value. Types of carbohydrates easily digested are called available carbohydrates. Available carbohydrates are easily digested into glucose, absorbed into the blood, and then metabolized by body cells. Includes available carbohydrates are monosaccharides, disaccharides, oligosaccharides, and starch. The higher the available carbohydrate content, the higher the GI value of the food[21].

The four types of rice with different processing have a glycemic index in the low category, which is less than 55. The different categories are based on the speed of digestion of food in the gastrointestinal tract, glucose absorption into the blood, and fluctuations in blood glucose levels. Foods with low GI are more challenging to digest and need more time to break down carbohydrates. This situation will slow down the rate of gastric emptying, and food suspension reaching the small intestine is also slower. Glucose absorption into the blood is slow, and fluctuations in blood glucose levels are also relatively low.

On the other hand, foods with a higher GI value are easier to digest, thus accelerating the rate of gastric emptying. The easy process of digesting carbohydrates accelerates glucose absorption into the blood and increases blood glucose levels[22]. When consuming foods with high GI values, the process of glucose absorption in the small intestine takes place more quickly and has the potential to increase blood glucose levels quickly as well. While consuming foods with low GI values, glucose absorption is slower and impacts the slow increase in post-prandial blood glucose levels and insulin response[23]. The response of post-prandial blood glucose levels to the glycemic index is influenced by the degree of insulin resistance, body fat, physical activity, and genetic factors[24].

With a lower glycemic index value, the digestion of carbohydrates into glucose is slower and affects the release of glucose into the blood, and fluctuations of glucose increase are slower. This condition will affect the increase in insulin secretion and glucose consumption by liver cells, decreasing blood glucose levels. Consumption of foods with a low glycemic index can increase insulin sensitivity and decrease the rate of glucose absorption. This situation can improve glycemic control in people with diabetes mellitus[25]. For people with diabetes, consuming rice as a staple food in sufficient quantities is safe for controlling blood glucose levels because rice has a low GI, and glucose is slow to digest and absorbed into the blood. Rice consumption with a balanced menu is more optimal in controlling blood glucose.

CONCLUSIONS

Rice processed traditionally has a glycemic index of 21.6 which increased to 24.7 after being stored at room temperature (without heating) for 12 hours. Meanwhile, rice that is processed in a modern way using a rice cooker has a glycemic index of 22.9 and increased to 36.4 after being stored in a rice cooker at a hot temperature for 12 hours. The four types of rice have a low GI value. Suggestions for further study on the analysis of rice glycemic index, it is necessary to analyze the amount of carbohydrates available in each type of rice to determine the portion of rice containing 50 grams of carbohydrates.

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Conflict of Interest and Funding Disclosure

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