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Review
The Utilization of Resistant Starch in Aking Rice Flour as Anti-Diabetic Food Ingredients

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Abstract

Aking rice is dried leftover rice that has been cooked and has not been consumed, so it will become stale rice then dried and considered by some people as household food waste. Thus far, aking rice has been used more for animal feed rather than being processed into human's food. At the same time, the prevalence of type 2 Diabetes Mellitus (DM) sufferers in developing countries including Indonesia is increasing. This review article will describe the opportunities for using aking rice to be processed into alternative food for people with type 2 diabetes. The writing of this article uses the Secondary Data Analysis (SDA) approach and literatur review in line with PRISMA. From the results of the review article, it is known that aking rice not only have a low glycemic index value, but also contains resistant starch (starch resistant) which can be beneficial for people with type 2 diabetes. The utilization of aking rice can through processed into aking rice flour. This flour can applied to the processing of various food products for people with diabetes type 2.

Keywords: food, diabetes mellitus, aking rice, resistant starch

Introduction

Rice is a main food source for Indonesian society. Therefore, almost all Indonesian people need rice every day. Indonesia is known as an agricultural country and is capable of being a self-sufficient country in rice. However, in its development, Indonesia has turned into a rice importing country from various rice producing countries. According to data (Badan Pusat Statistik, 2017), Indonesia's total rice imports reached 2.25 million tons. This amount is needed in order to ensure the food sufficiency of the Indonesian people.

In the midst of conditions for rice imports whose value is quite large, it turns out that Indonesia is also a country that wastes a lot of food including rice in vain. According to the (Barilla Center for food & nutrition, 2017), Indonesia include in the group of countries that produce food waste quite high in the world after Uni Emirates Saudi Arabia. According to these data , every Indonesian citizen throws out 300 kg of food waste per year. If this value is multiplied by the total population of Indonesia, which amounts to 260 million people, it will produce a fantastic food waste value of around 13 million tons per year. The food waste produced includes rice. If it is assumed that the population from the middle to upper class in Indonesia is as many as 140 million people, always throwing 3 grains of rice at every meal, then in one meal alone, 420 million grains of rice have been collected. If it is calculated mathematically, for example one kilogram of rice is equivalent to 50 thousand grains of rice, then in one meal the Indonesian population has wasted as much as 8.4 tons of rice per (Kumoro & Purbasari, 2014).

Aking rice is leftover rice that can not be consumed in the household, clean rice that is still in the rice cooker has the potential to become waste, even though the rice has been cultivated and cooled so that it has a high enough resistant starch content. Rice that is processed into rice can be reprocessed into functional food ingredients, such as aking rice. Aking rice is a food that has a low glycemic index. Food with a low glycemic index is food with resistant starch. There are 5 types of resistant p ati group based on the processing method. Based on this grouping, rice is included in type III resistant starch . This resistant starch has undergone a heating and cooling process at a certain time. This type of starch can be useful for lowering the glycemic index if after experiencing a digestive process in the body (Dupuis, Liu, & Yada, 2014).

According to (Lockyer & Nugent, 2017) resistant starch has beneficial physiological effects for health such as prevention of colon cancer and has hypoglycemic effects (lowers blood sugar levels) and hypocholesterolemic effects (lowers blood cholesterol levels). Efforts to use aking rice as an alternative to developing functional food products are very feasible. This will be an alternative solution so that aking rice will have a use value to be used as

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a raw material for food products, for example into aking rice flour (Kumoro & Purbasari, 2014).

At the same time, people's lifestyle affects their diet. Food is no longer considered merely the fulfillment of basic needs but also as a lifestyle . Most people have a negative habit is to tend to choose the consumption of foods such as fast food and junk food with no regard to the number, type and schedule when eating food. This condition is exacerbated by the lack of activity or exercise that is useful for maintaining body fitness. This lifestyle will have bad consequences for public health, such as an increase in prevalence of people with Diabetes Mellitus (DM) (Gustawi, Norviatin, & Alibasyah, 2014). According to (Fatimah, 2015) DM is a metabolic disorder, which is characterized by an increase in blood sugar due to decreased insulin secretion by pancreatic beta cells and / or disruption of insulin function (insulin resistance). This increase in blood sugar is caused by consumption of foods that contain high sugar. Foods that can raise blood glucose levels quickly have a high glycemic index (GI), on the other hand, foods that raise blood glucose levels slowly have a low GI. So, that needs further research and studies for knowing food value of aking rice flour, identifying the amount of resistant starch in aking rice and analyze the benefits of flour nasi aking .

Writing Method

This article uses the Narrative Review method with the Secondary Data Analysis (SDA) approach. SDA is a research method using secondary data as the main data source. Articles have referred to the literatur review notes . The published articles used from national and international indexed journals with the keywords aking rice, resistant starch, diabetes millitus. This article review methods based on PRISMA (Optional Reporting Items for Systematic Review and Meta Analysis Guidlines).

In searching journals using databases of google schoolar, pubmed and ncbi. By using keywords of food waste, dryed rice, diabetic type 2, rice, glycemic index, resistant starch. In the process of searching for journals , 60 journals were identified . Then, after making the inclusion, 21 journals were out because they were not in accordance with the theme. Another screening was carried out on 39 journals that were selected from the inclusion process and found 2 journals that did not match the theme and were not full text. Therefore, this article used 37 journals. The flow of writing is below.

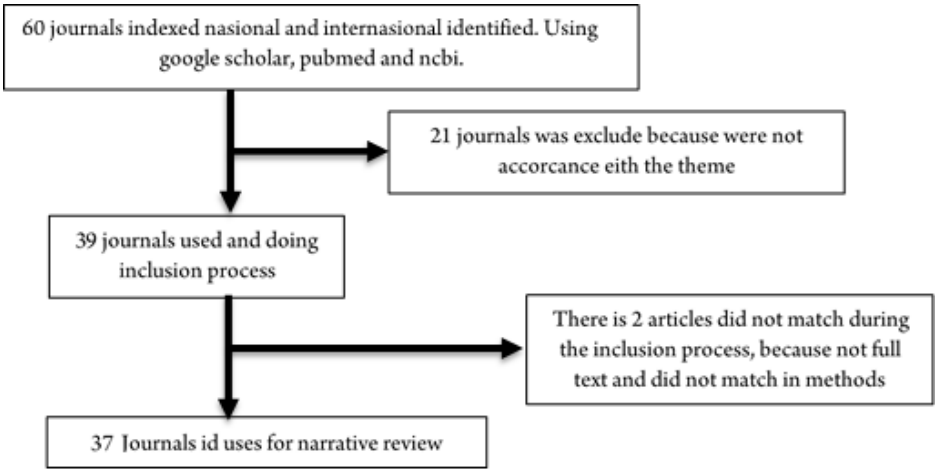

Figure 1. Schematic of Narrative review

Results And Discussion

Aking Rice as a Resistant Starch

White rice is a staple food for Indonesians. Almost all Indonesians consume white rice every day with a frequency of 2-3 times per day. In the table below is the nutritional content of white rice per 100 grams of food according to SNI .

Table 1. SNI for Nutritional Content of Rice

Nutrient content	Amount (%)
Carbohydrate	40.0 - 40.8
Protein	2.1 - 3.0
Fat	0.1 - 0.5
Water	57.0 - 58.0
Iron	22.2 - 23.0
Other minerals	1.0 -2.0

(Badan Standarisasi Nasional, 2009)

The water content in aking rice is less than the water content in white rice, this is due to the drying process in aking rice. In addition, the carbohydrate content in rice is known to be lower, such as 8.31%, while the metabolic energy in rice is known to be 3,100 kcal/ kg. Based on the results of the examination, the carbohydrate content in rice aking was 8.31%, while on the examination of normal rice carbohydrates was 10.72%. There is a difference of 2.41 % due to several factors such as the type of rice , the drying time , and the quality of the rice aking (Ariyadi & Anggraini, 2010).

There are 5 types of resistant p ati group based on the processing method. Type 1 is a naturally occurring starch that is obtained from plant cells and the food matrix, for example grains and cereals. Type 2 resistant starch is starch that is naturally very resistant to the digestive system and generally granules are crystalline. The next cell , resistant starch type 3, is starch that is etrogradated through a heating process followed by a cooling process . Then type 4 resistant starch is chemically modified starch such as starch ester and cross-linked starch. Finally, type 5 resistant starch is starch that interacts with lipids, so that amylose forms a single helical complex with fatty acids and fatty alcohols . P ati resistant which has undergone a process of heating and cooling at certain times accompanied can lower the glycemic index is a resistant starch type 3, for example parched rice (Dupuis et al., 2014).

Resistant starch is a food that is difficult to digest in the small intestine so that it has a good function for health (Herawati, 2011). Gelatinized starch then goes through cooling, freezing, roasting or frying causing the starch to etrogradate (Marsono, 2002). The making of aking rice is done through a heating process then cooling and then mashed to form flour. Products with fortified resistant starch can increase the need for fiber intake and can enrich food (Raigond, Ezekiel, & Raigond, 2015). So that it can enrich the nutrients contained in food ingredients, especially dietary fiber.

Aking Rice Flour as an Anti Diabetic Functional Food

A lifestyle of consuming too much food and little activity can increase the risk of obesity, type 2 diabetes mellitus , and colon disease (Kumar et al., 2018). Diabetes mellitus is a metabolic disease that has hyperglycemic characteristics (high blood glucose) that occurs due to abnormalities in insulin secretion or insulin resistance (Gustaviani, 2016). The prevalence of people with diabetes in Indonesia is quite high and increase in a few year that is 1.5 to 2.3% in the population aged more than 15 years old. According to WHO, Indonesia occupies the order of the 4th largest in the world (WHO, 2012). Diabetes mellitus is related to the condition of blood glucose levels 2 hours after eating (Triana & Salin, 2017).

The habit that must be carried out by diabetes mellitus sufferers is to always apply the 3J diet, such as the right amount, the right type and the right schedule (Tjokroprawiro, 2006). Diabetes mellitus type 2 is caused by the pancreas that cannot work properly, resulting in poor quality insulin. This makes sugar unable to enter the cells, so that blood sugar levels increase (Hanstandra, 2017). Patients with type 2 diabetes mellitus usually have difficulty finding food items that have low glucose levels, because in the postprandial phase or two hours after eating, they experience an increase in blood glucose which is not good for the sufferer. Food ingredients needed by people with diabetes mellitus are materials that can inhibit the increase in blood glucose levels, which are low on the glycemic index and contain resistant chests. It is also influenced by the carbohydrate digestion system in the body.

According to (Englyst & Englyst, 2005), the digestion mechanism of carbohydrates in the digestive system

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is influenced by the carbohydrate components in food. The carbohydrate components in food are influenced by the chemical identity of the food and the content in the food. The identity in question is the type of glucose contained, the type and so on. Then the food content in question is the nutrients that are naturally present in food and the food content that is formed as a result of the existing cooking process. This then affects the digestion process of carbohydrates.

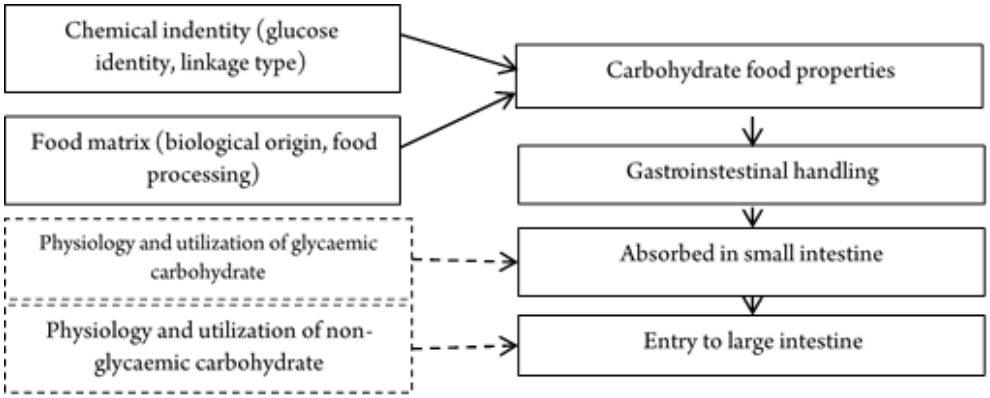

Figure 2. Schematic of Carbohydrate Digestion
(Englyst & Englyst, 2005)

The picture above is a schematic of carbohydrate digestion in the digestive system. Resistant starch is a type of carbohydrate in which the composition of amylose and amylopectin is greater. In the digestive system, amylose is absorbed slowly and vice versa, amylopectin is absorbed very quickly after retrogradation (Raigond et al., 2015). So that resistant starch is difficult to digest in the small intestine . After undergoing several heating and cooling processes, a food material will undergo retrogradation and gelatinization so that it will change the structure of amylose and amylopectin . This makes amylose and amylopectin undetectable by enzymes in the small intestine. The structure of resistant starch type 3 as a whole is hydrated starch granules, so that the branch chains of both have changed. Normally the polymer helix chain has 6 glucose units, however, after going through this process the polymer chain model changes to a double helix (Sajilata, Singhal, & Kulkarni, 2006). Therefore, resistant starch is difficult to digest in the small intestine. Here is the structure of type 3 resistant starch.

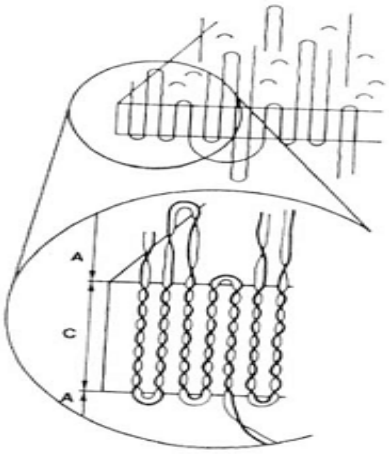

Figure 3. Double helical polymer chain structure in resistant starch type 3
(Sajilata, Singhal, & Kulkarni, 2006)

There is a real reason why blood sugar and insulin levels in healthy people can decrease is the fermentation process of resistant starch in the large intestine (Robertson, Harmon, Tran, Tanaka, & Takahashi, 2003) so that slow digestion will slow down glucose absorption (Aigster, Duncan, Conforti, & Barbeau, 2011) and insulin

secretion (Ma & Boye, 2018). Several studies have even explained that consuming resistant starch can increase good bacteria in the gut such as Lactobacillus and Bifidobacterium, Lachnospiraceae, Ruminococcaceae, Clostridium and Akkermansia in the intestines of mice (Meenu & Xu, 2019).

Increasing the consumption of foods that contain a low glycemic index can reduce the risk of diabetes mellitus and obesity, because they contain high fiber and resistant starch (Gentile et al., 2015). Resistant starch provides many benefits for lowering blood sugar and insulin levels and has a good impact on digestion for both people with diabetes mellitus and without diabetes mellitus (Meenu & Xu, 2019). According to research by (Chiu & Stewart, 2013) rice with high resistant starch and low resistant starch does not have a significant impact on the glycemic index of healthy people and only results in a feeling of fullness. There is also no difference in glucose levels between plainly processed rice and aking rice (Ishmah & Anugrah, 2020).

Table 2. Starch resistant as antidiabetic

Types of Resistant Starch	Food ingredients	Resistant Starch	Non Resistant Starch	Researcher
Type 1	Rice flour	2.15%	71.63%	Toma & Pokrotnieks (2006); Wells et al. (2008); Vatanasuchart et al. (2010); Vatanasuchart et al. (2012); Moongngarm (2013) .
	Red bean flour	9.54%	24.54%	
	Green bean flour	2.33%	23.40%	
	Corn flour	1.16%	35.07%	
	Soy flour	7.84%	41.73%	
Type 2	Banana flour	6.14%	51.99%	
	Potato flour	3.19%	49.35%	
Type 3	Cassava flour	4.12%	59.61%	
	Wheat flour	3.69%	30.27%	
	Aking rice flour	13.9%	-	Ha, AW, et al . (2012)

Aking rice is a resistant starch that has undergone retrogradation so that the digestive system will be difficult to break down into glucose so that it can reduce glucose levels in the blood. Aking rice innovation into a useful ingredient is aking rice flour. Aking rice flour has nutritional content, such as carbohydrates 83.19% (w / w), amylose 29.70% (w / w), fat 0.40% (w / w), protein 3.36% (w / w) , fiber 0.11% (w / w), 40% (w / w) and water 12.37% (w / w) (Kumoro & Purbasari, 2014).

Clean Aking rice has a higher resistant starch content than white rice, such as 13.9 ± 0.98 . Rice stored at 4 o C for 24 hours had a lower glycemic index (GI) and starch digestibility than freshly cooked rice (Ha, Han, & Kim, 2012). Clean aking rice also contains more carbohydrates compared to stale aking rice. The advantages of aking rice flour are that it is high in resistant starch, making it difficult to absorb into glucose in the body, slows down insulin secretion, the processing method takes into account hygiene sanitation because for human food, it is made from uneaten rice or aking rice, not leftover rice such as animal feed.

The development of food fortification will continue to develop in the future. Food fortification is the addition of a substance or other material to increase the nutritional content of a food product . Below are some of the fortifications of resistant starch in food products.

Table 3 Fortification of resistant starch in food products

Researcher	Year	Research result
Yamada Y, et al.	2005	Substitution of 6 g of resistant starch in bakery products can significantly inhibit insulin secretion and increase in postprandial blood glucose in subjects with fasting blood glucose> 110 mg / dl.
Raigond, P., et al.	2015	Products fortified with resistant starch can increase the need for fiber intake and can enrich food products.

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Meenu, M., et al.	2019	Substitution of resistant starch as much as 38% can reduce post-prandial blood glucose levels.
Lin, CH, et al.	2015	The staple food formula PPB-R-203 has a composition of 10% etrogradated starch, 70% amylopectin and 20% amylose which can increase insulin resistance.
Bodinham CL, et al.	2010	Consumption of 48 grams of resistant starch supplement did not have a significant effect on postprandial blood glucose response in healthy people.
Penn-Marshall, et al.	2010	Consumption of more than 12 grams of resistant starch reduces the risk of T2DM in the African American population

Fortification of resistant starch can be done by drying it and converting it into flour and then substituting it for the basic ingredients of a food. For example, bread with a substitution of resistant starch by 38% can reduce post-prandial blood glucose levels but there is no association with insulin secretion in healthy people (Meenu & Xu, 2019). In a study, substitution of high-resistant starch in bread consumed more than 12 g / day by the African American community, can reduce the risk of developing type 2 diabetes mellitus (Penn-Marshall, Holtzman, & Barbeau, 2010)Bridgewater, NJ, USA.

Conclusion

Based on analysis of several scientific articles can be concluded that innovation aking rice flour safe for consumption in patients with type 2 diabetes mellitus, high resistant starch and low glycemic index in aking rice will be very good for patients with diabetes mellitus. Then, developing food products fortified resistant starch can inhibit postprandial blood glucose levels and increase insulin secretion.

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