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Are Glycaemic Response, Glycaemic Index, and Glycaemic Load of Traditional Palm Sugar (Arenga pinnata) Different from Cane Sugar?: An Oral Glucose Tolerance Test

Apakah Respon Glikemik, Indeks Glikemik, dan Beban Glikemik Gula Semut (Arenga pinnata) Berbeda dengan Gula Pasir?: Uji Toleransi Glukosa Oral

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ABSTRACT

Background: Palm sugar *(Arenga pinnata)* is believed to benefit people with diabetes mellitus since they believe it has a low glycemic index. However, the total carbohydrates in palm sugar, particularly sucrose, are high. Thus, offering palm sugar to diabetic people still needs further studies.
Objectives: The purpose of this study was to examine differences in the glycemic response, glycemic index, and glycemic load of palm sugar compared to cane sugar.
Methods: This study used an experimental design. Measurement of the oral glucose tolerance test (OGTT) through the finger-prick capillary blood test method. The main materials in this study were commercial white cane sugar as reference food and traditional palm sugar product of Lebak District, Banten Province, as a test food. Reference food and test food were provided equivalent to 50 g available carbohydrate dissolved in 250 ml mineral water subjected to 5 men and 5 women. The glycemic response was determined by the area under the curve (AUC) of the trapezoid method. The difference in glycemic response between the reference food and the test food was assessed using the independent sample t-test.
Results: The peak of the increase in blood glucose occurred at 30 minutes. There was no difference in glycemic response between the reference food and the test food (p-value 0.685). The palm sugar glycemic index was 98.71 and was categorized into the high glycemic index category. Meanwhile, the glycemic load of palm sugar and cane sugar was 11.80 and 12.22, those categorized into the medium glycemic load category.
Conclusions: No differences in glycemic response between palm sugar and cane sugar. The glycemic index of palm sugar was considered high and was not different from cane sugar. The glycemic load of palm sugar and cane sugar was classified as moderate due to the small serving size. Using palm sugar less than cane sugar was expected to provide a lower glycemic response, glycemic index, and glycemic load.

ABSTRAK

Latar Belakang: *Gula semut aren (Arenga pinnata) dipercaya memberikan manfaat untuk kesehatan dan baik diberikan pada orang dengan diabetes melitus karena memiliki indeks glikemik yang rendah. Meskipun memiliki indeks glikemik yang rendah, total karbohidrat dalam gula semut aren, terutama sukrosa tergolong tinggi. Dengan demikian pemberian gula semut kepada orang yang mengalami diabetes melitus masih membutuhkan penelitian lebih lanjut.*
Tujuan: *Penelitian ini bertujuan untuk mengkaji perbedaan respon glikemik, indeks glikemik, dan beban glikemik gula semut aren dibandingkan gula pasir.*
Metode: *Penelitian ini menggunakan rancangan eksperimental. Pengukuran oral Glucose Tolerance Test (OGTT) menggunakan metode Finger Prick Capillary Blood Test. Bahan dalam penelitian ini adalah gula pasir kristal putih (gula tebu) kemasan sebagai pangan acuan dan gula semut (aren) tradisional produksi Kabupaten Lebak, Provinsi Banten sebagai pangan uji. Pangan acuan dan pangan uji diberikan setara dengan 50 gr available carbohydrate yang dilarutkan dalam 250 ml air mineral. Subjek penelitian berjumlah 10 orang yang terdiri dari 5 orang laki-laki dan 5 orang perempuan. Respon*

glikemik dihitung dengan menghitung luas area bawah kurva (Area Under Curve, AUC) metode trapezoid. Perbedaan respon glikemik antara pangan acuan dan pangan uji dikaji dengan independent sample t-test.

***Hasil:** Puncak peningkatan glukosa darah terjadi pada menit ke-30. Tidak ada perbedaan respon glikemik antara pangan acuan dengan pangan uji (p value 0,685). Indeks glikemik gula semut 98,71 dan termasuk dalam kategori tinggi. Beban glikemik gula semut 11,80 dan gula pasir 12,22 yang termasuk dalam kategori sedang.*

***Kesimpulan:** Tidak ada perbedaan respon glikemik antara gula semut aren dengan gula pasir. Indeks glikemik gula semut aren tergolong tinggi dan tidak berbeda jauh dengan gula pasir. Beban glikemik gula semut aren dan gula pasir tergolong sedang yang disebabkan oleh takaran saji yang kecil. Terdapat kemungkinan bahwa penggunaan gula semut aren dapat lebih sedikit dibandingkan gula pasir sehingga diharapkan respon glikemik, indeks glikemik, dan beban glikemik yang dihasilkan menjadi lebih rendah.*

***Kata Kunci:** Gula Semut Aren, Arenga Pinnata, Respon Glikemik, Indeks Glikemik, Beban Glikemik*

INTRODUCTION

Palm sugar is widely consumed because of the widespread news stating that this sugar provides health benefits and is suitable for people with diabetes mellitus. However, there has been no health research regarding the administration of palm sugar on the blood glucose levels of people with diabetes mellitus.

Palm sugar is believed to have a low glycemic index (GI), so it is considered suitable for people with diabetes, but there is no official statement regarding the glycemic index of palm sugar. The glycemic index value was categorized into three categories, namely low (GI 55), moderate (GI 56-69), and high (GI 70). Foods with low GI can play an essential role in nutritional management for diabetes, weight loss, exercise performance, and lower risk of non-communicable diseases[1,2]. The study by Riawan (2017) reveals that the glycemic index of crystal palm sugar is 43.61, and printed palm sugar prints 62.47[3]. If it refers to those three categories, palm sugar is classified as a low GI food.

Even though it has a low GI, the carbohydrate content in palm sugar is still relatively high. The total carbohydrates in palm sugar are 92.62% and sucrose 86.6%, while the fructose content is very low, about 0.83%[3]. GI Fructose is 19; the greater fructose content leads to the lower GI of the food[4]. Sucrose is one of the carbohydrates that potentially elevates blood glucose compared to glucose and fructose in healthy and diabetic people[5,6]. Thus, offering palm sugar to people with diabetes mellitus still requires further research.

METHODS

This study used an experimental design. The oral glucose tolerance test (OGTT) was conducted at the Nutrition Laboratory and Public Health Laboratory, Faculty of Health Sciences, UPN Veterans Jakarta. The study was conducted in December 2020 by implementing health protocols during the COVID-19 pandemic. The study received ethical approval from the Veteran National Development University of Jakarta Health Research Ethics Commission number 2853/XII/2020/KEPK.

The materials used in this study were commercial white crystal sugar (cane sugar) as a reference food and traditional crystal palm sugar produced by Lebak District, Banten Province, as a test food. Blood glucose measurement was conducted using the finger-prick capillary blood test method via a portable blood glucose meter. The reference food and test food were equivalent to 50 g of available carbohydrates dissolved in 250 ml of mineral water. Available carbohydrates were absorbable and metabolizable by the human body, whose value was known by calculating the difference between total carbohydrates and dietary fiber[7]. The serving size of reference food and test food was calculated formula = (50 g × 100) ÷ available carbohydrate content. The results of the serving size calculation can be seen in Table 1.

Table 1. Serving size of reference food and test food

Sample	Carbohydrate content per 100 g	Fiber content per 100 g	Serving size (g)
Reference food (Cane sugar)	94	0	53.19
Test food (Palm sugar)	92	0	54.34

Carbohydrate and dietary fiber levels of cane sugar and palm sugar were known using data in the Indonesian Food Composition Table of 2017[8]. The serving size of cane sugar and palm sugar was decided up to 53 g and 54 g.

The subjects were 10 people consisting of 5 men and 5 women. The sampling technique used was purposive to facilitate the ongoing research during the COVID-19 pandemic. Subject selection and research stages referred to the glycemic index methodology[9]. The inclusion criteria of research subjects were aged 18-30 years, had a normal Body Mass Index (BMI) of[10] (18.5-22.9 kg/m^2), had no history of diabetes and normal fasting blood glucose levels (GDP) according to PERKENI[11] (60-100 mg/dL) and did not experience digestive disorders. The exclusion criteria for this study were that the subject had a particular disease (proven by a doctor's diagnosis) and consumed foods, drinks, or drugs with hypoglycemic effects.

The stages of this study were: (1) Subjects were asked to fast for at least 10 hours (still allowed to consume water); (2) The researcher took the blood of the samples at minute 0 (end of fasting) with the finger-prick capillary blood sample method and measured their blood glucose levels; (3) Intervention of reference food (cane sugar) solution which was consumed within 5 minutes;

(4) Subjects' blood glucose levels were taken at 15, 30, 45, 60, 90, and 120 minutes using the finger-prick capillary blood sample method; (5) Washing out for 7 days and in the afternoon between the 7th and 8th days, the samples were asked to do fasting for at least 10 hours; (6) On the 8th day, the researcher took the blood sample of the study at minute 0 (end of fasting) using the finger-prick capillary blood sample method and measured blood glucose levels; (7) Provision of test food solution (palm sugar) which was consumed within 5 minutes; (8) Subjects' blood glucose levels were taken at 15, 30, 45, 60, 90, and 120 minutes by finger-prick capillary blood sample method.

The glycemic response was calculated by calculating the area under the curve (AUC), with the trapezoid method. The difference in glycemic response between the reference food and the test food was assessed by an independent sample t-test. The glycemic index of palm sugar was presented as a percentage by comparing the AUC area of the test food with the standard food. The glycemic load was calculated by the following formula=(glycemic index × carbohydrates (g))÷100[12].

Table 2. Characteristics of subjects based on gender, age, weight, height, and BMI (Body Mass Index)

Subject	Gender	Age (y.o)	Weight (kg)	Height (cm)	BMI (kg/m^2)
1	Female	22	48.7	151.5	21.22
2	Female	22	49.3	151.0	21.62
3	Female	22	46.9	148.5	21.27
4	Female	21	57.2	166.0	20.76
5	Female	25	54.0	153.5	22.92
6	Male	23	63.2	167.0	22.66
7	Male	31	72.3	178.0	22.82
8	Male	20	49.7	162.0	18.94
9	Male	21	56.3	164.5	20.81
10	Male	21	50.8	159.0	20.09
Average		22	54.84	160.10	21.31

From Table 2, the average age of the research subjects was 22 years, weighed 54.84 kg, height of 160.10 cm, and had a normal nutritional status based on the BMI under the WHO category for the Asian population[10].

Blood Glycemic Response of Reference Food and Test Food

Blood glycemic response is the effect of a food on blood glucose after consuming that food[12]. In this study, the reference food was sugar cane solution, and the test food was palm sugar solution. The reference food and the test food were given in the same amount, 50 g dissolved in 240 ml of water, to determine the difference in blood glycemic response when consuming cane sugar and palm sugar in the same quantity. The blood glycemic response curves for reference and test foods are presented in Table 2.

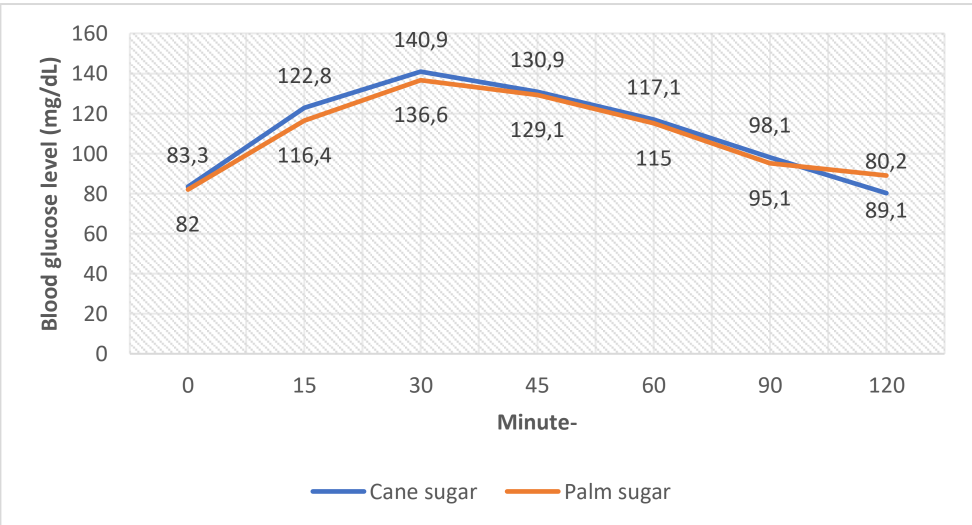

Figure 1. Curve of blood glycemic response for cane sugar and palm sugar

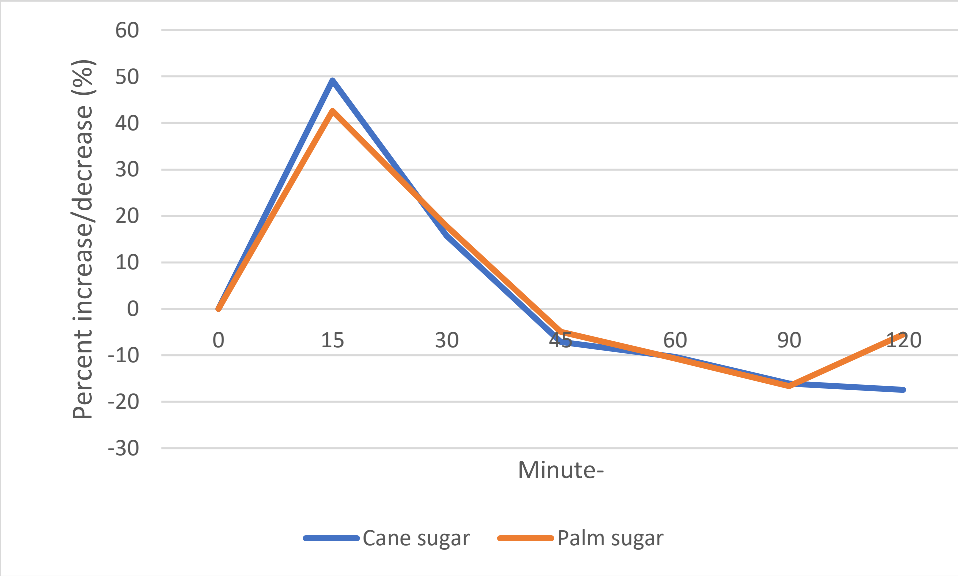

Figure 2. Percent increase or decrease in blood glucose

Based on Figure 1, it was known that at the 15th minute to the 90th minute, the blood glycemic response of palm sugar was below the cane sugar, while at the 120th minute, the glycemic response of palm sugar was higher than the cane sugar. The blood glucose peak in palm sugar and cane sugar was at the 30th minute and decreased at the 45th to the 120th minute. From Figure 2, it can be seen that the highest average percentage increase in blood glucose in the cane sugar and palm sugar occurred at the 15th minute was 49.15% and 42.59%. At the 120th minute, the blood glucose level in the palm sugar treatment was higher than the cane sugar, and the percentage reduction in blood glucose in the palm sugar treatment was lower (5.5%) than the cane sugar (17.43%). This shows that the glycemic control of palm sugar was slightly better than cane sugar.

The results of the area under the curve (AUC) calculation are presented in Table 3. From the Shapiro-Wilk normality test results, the data were normally distributed, then continued with the independent sample t-test.

Table 3. AUC of cane sugar and palm sugar glycemic response

Type of sugar	Total AUC	*p-value*
Cane sugar	13,324.5 ± 1,016.57	0.685
Palm sugar	13,123.5 ± 1,156.92	

Based on Table 3, it was known that the p-value > 0.05, so there was no difference in the glycemic response between the reference food (cane sugar) and palm sugar. According to Brouns et al. (2005)[9] adapted from Arvidsson-Lenner et al. (2004),[13] stated that several factors derived from food affect the glycemic response of a food. Those factors include the gross matrix structure, cell wall structure and starch, granular starch structure, amylose and amylopectin content, gelling food fiber, organic acids such as acetic acid, amylase inhibitors, the composition of monosaccharides, the composition of molecular carbohydrates, and content of resistant starch. Factors affecting the structure of the gross matrix are grinding, and factors affecting the granular structure of starch are heating, both of which cause an increase in glycemic response and glycemic index. In palm sugar processing, grinding and heating elevate the glycemic response and the glycemic index of palm sugar, especially if the processing is still using traditional methods that allow overheating.

Glycemic Index

The glycemic index is a classification of various carbohydrate sources and high-carbohydrate foods in the diet according to their effect on postprandial glycemic[1]. Foods high in the glycemic index will cause higher postprandial blood glucose peaks and a more significant blood glycemic response at 2 hours postprandial than low glycemic index foods[2]. The glycemic index is also the glycemic response of several available carbohydrates from a test food to available carbohydrates from standard foods consumed by the same subject[14–16]. Carbohydrates with a low glycemic index are digested and absorbed slowly, resulting in a low glycemic response. Meanwhile, carbohydrates with a high glycemic index will be digested and absorbed immediately to cause a high glycemic response. Foods with a low glycemic index often have beneficial effects on health, such as lowering the risk of chronic disease[9].

In a healthy population, postprandial glycemic effect markers such as glycemic index and glycemic load are associated with type 2 diabetes in a healthy population[17]. Eating foods with a high glycemic index combined with low fiber consumption is associated with an increased risk of type 2 diabetes[4,17] with a relative risk of 1.27 per 10 glycemic index units in a 2000 kcal diet [17]. Therefore, the selection of low glycemic index foods is often made as part of nutritional management to prevent and maintain diabetes mellitus. Foods high on the glycemic index also increase the risk of some types of cancer. Turati et al. (2019) show that someone who eats a high glycemic index diet has a 1.2 times risk of developing colon cancer and 1.25 times of bladder cancer[18]. Consumption of low glycemic index foods can also benefit weight loss, weight gain, and obesity, improve reproductive conditions in women, polycystic ovary syndrome, and cardiovascular and blood vessel health. A low glycemic index diet was associated with a significant increase in salivary testosterone. A diet high on the glycemic index can increase cortisol levels. Changes in the glycemic index can affect overall energy intake and health[19].

Table 4. Glycemic Index of cane sugar and palm sugar

Type of sugar	Glycemic index (%)
Cane sugar	100
Palm sugar	98.71

The glycemic index of a food is categorized into 3, low (<55), moderate (56-69), and high (≥70) [20,21]. Based on table 4, the glycemic index of palm sugar is high and slightly lower but not significantly from the reference food (cane sugar). This is probably due to the high sucrose content in palm sugar. A study by Pontoh (2013) related to the sucrose content of commercial palm sugar, it was found that the sucrose content of commercial palm sugar (a type of sugar) ranged from 79.30 - 94.36%[22], relatively nit significant different from the sucrose content of cane sugar (94 – 98.5% sucrose)[23]. In addition, the sucrose content in palm sugar is higher than palm sugar solid (printed). This was caused by the addition of sugar (sucrose) in commercial palm sugar products[22].

Glycemic Load

The glycemic index compares the potential for increasing glucose from carbohydrates in the same amount, but the glycemic index does not represent the number of carbohydrates in a food serving. The glycemic load is the product of the glycemic index value of food and the total carbohydrate content, representing the glucogenic potential of a food[16]. Like the glycemic index, a person who eats a diet with a high glycemic load is at risk of developing type 2 diabetes[24] with a relative risk of 1.26 per 80 g/dl glycemic loads on a 2000 kcal diet[17].

Table 5. Glycemic load of cane sugar and palm sugar

Type of sugar	Serving size (g)*	Carbohydrates content per serving size (g)	Glycemic Load
Cane sugar	13	12.22	12.22
Palm sugar	13	11.96	11.80

*According to serving sizes for sugar and fruit from the Indonesian Food Composition Table (Instalasi Gizi &Pusat Diabetes dan Lipid Jakarta, 2012)

The glycemic load is classified into 3 categories, namely low (≤10), moderate (11-19), and high (≥20)[26]. Based on Table 5, it can be seen that both the reference food and palm sugar have a moderate glycemic load. Even though cane sugar and palm sugar have a high glycemic index and carbohydrate content, the serving size is quite small in daily consumption. However, the higher the quantity of food or drink consumption with sweeteners (cane sugar and palm sugar), the higher the glycemic load.

Although in this study, the glycemic response, glycemic index, and glycemic load of palm sugar did not appear to be significantly different from cane sugar, the recognition of the research subjects stated that the palm sugar solution was much sweeter than the cane sugar. From the weighing results, 50 g of palm sugar looks about 2 times more than 50 g of cane sugar. Thus, the use of palm sugar as a sweetener can be less (about 50%) than cane sugar; furthermore, the glycemic response, glycemic index, and glycemic load produced after consuming palm sugar can be lower than cane sugar.

CONCLUSION

There was no difference in glycemic response between palm sugar and cane sugar. The glycemic index of palm sugar was relatively high and not different from cane sugar. The glycemic load of both sugars was moderate due to the small serving size. Although the three postprandial glycemic markers between those sugar did not have significant differences, it was possible to consume palm sugar less than cane sugar to get the same level of sweetness. So, it was expected that the glycemic response, glycemic index, and the resulting glycemic load will be lower.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

All authors have no conflict of interest in this article.

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