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BREADFRUIT FLOUR, FOOD TO LOWER BLOOD SUGAR LEVELS IN MICE MODEL DIABETES MELLITUS

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ABSTRACT
Consumption of foods with high amylose content (>25%) as well as a low glycemic index (<55) is able to improve the insulin sensitivity of people with diabetes mellitus. Breadfruit has in about 23-60 which means that breadfruit is safe to consume. The purpose of this research is to find out the levels of reduced sugar, amylose, and blood sugar levels mice after being fed breadfruit flour. This research used a Complete Randomized Design using 5 treatments namely normal control group (KN), negative control (K-), positive control (K+), STZ + breadfruit flour dose 5 g (P1) and STZ + breadfruit flour dose 10 g (P2). Breadfruit is taken and then processed into breadfruit flour, after which testing of reduced sugar content and amylose breadfruit flour. Before treatment, all mice were measured for initial glucose levels. After that in groups K (-), K (+), P1, and P2 injected STZ on days 1, 2, and 3. After 3 days, the blood glucose level (post-STZ) was measured again, then compared to the blood glucose level on the first day before being given STZ. If there is an increase in blood glucose levels of mice that is to ±128 mg / dL then mencit is considered to be diabetic. Then in group K (+) drug given Metformin, P1 and P2 were fed breadfruit flour with a predetermined dose for 7 days. The results showed that the sugar content of reduced breadfruit was cut by 3.26%. While the level of amylose in breadfruit flour is 19.3%. Breadfruit flour can also lower the sugar content of mice.

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INTRODUCTION

The prevalence of Diabetes Mellitus (DM) shows an increase from year to year (Sudyasih & Asnindari, 2021). Data from the International Diabetes Federation in 2017 shows that Indonesia is currently ranked 6th in the world with the largest number of diabetics, namely 10.3 million people (Azriful et al., 2018). The high prevalence of

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diabetes mellitus is generally caused by an imbalance in food intake, where consumption of foods that tend to be high in fat, sugar, and low in fiber can lead to obesity and result in an increase in blood glucose 2 hours postprandial.

Diabetes mellitus cannot be cured but can be managed so that blood sugar levels can be controlled. Management of DM patients can be carried out with non-pharmacological and pharmacological therapies (Yanti & Mertawati, 2020). Non-pharmacological management can be done by adjusting diet, exercise and consuming herbal ingredients (Festi, 2020). Meanwhile, pharmacological management can be in the form of oral hypoglycemic drugs or antihyperglycemic agents and insulin, but these treatments have unwanted side effects such as swelling in the peripheral areas. This reason has led to increased public interest, especially DM sufferers, in using non-pharmacological therapies using natural ingredients, one of which is through the consumption of foods that do not cause a rapid increase in blood glucose (Franz, 2012).

Consumption of foods with high amylose content (> 25%) and low GI (<55) can improve insulin sensitivity in people with diabetes mellitus, reduce the rate of absorption of glucose, and is beneficial in controlling blood glucose so that it can reduce the risk of complications in patients with type 2 DM (CARELLA, n.d.). Breadfruit (Artocarpus communis) is a local plant whose distribution is very wide and evenly distributed in tropical climates, including Indonesia (Masita et al., 2017). Breadfruit is an important commodity because of its high productivity (Omobuwajo, 2003). Nonetheless, the use of breadfruit is still limited due to difficult storage problems in fresh fruit form (Pratiwi, 2013). So far, breadfruit has not been used properly, only limited to being used traditionally, namely by boiling, frying, or making chips.

Breadfruit flour is gluten-free flour produced from naturally cultivated breadfruit. This flour contains high calcium and fiber and is suitable as a substitute for wheat flour. This flour can be used to make pastries, cakes, brownies, and market snacks (Sukandar et al., 2014). Breadfruit has a GI of around 23-60, which means that breadfruit is safe for consumption. The glycemic index (GI) of food is influenced by the amount of amylose (Prahandoko et al., 2013).

Amylose is a straight chain polymer of glucose connected by α-(1,4)-glycosidic bonds. Amylopectin is a simple, branched, open structure sugar polymer(Santos et al., 2016). The higher amylose content causes slower digestion because amylose is a glucose polymer that has an unbranched structure a more crystalline structure with more extensive hydrogen bonds). Amylose also has stronger hydrogen bonds than amylopectin, making it more difficult to be hydrolyzed by digestive enzymes (Behall & Hallfrisch, 2002). The purpose of this study was to determine the provision of breadfruit flour as feed to decrease blood sugar levels in mice.

METHODS

The method used in this study is the mixed methods. Mixed methods are research methods that combine quantitative methods with qualitative methods to be used together

in a research activity, so that more comprehensive, valid, reliable and objective data are obtained.

In this study, quantitative data played a role in obtaining measurable data that was descriptive, comparative, and associative. Qualitative data plays a role in proving, deepening, expanding, weakening, and aborting quantitative data that has been obtained.

The type of research used in this study is with observational analytics with a cross-sectional design. This study compares independent variables with dependent variables at the same time which aims to determine the relationship between independent variables (completeness of medical records and conformity of diagnosis codes with ICD 10) with dependent variables (approval of BPJS claims).

Based on the concept of variable thinking as stated above, the variable mindset studied is compiled as follows: Location and Time of Research This research was carried out in the Medical Record Management section of Citama Hospital. The implementation time of this study is July 2022 – August 2022. C. Population and Research Samples The population in this study is the entire inpatient medical record file of the BPJS patient inpatient care unit in January 2022-May 2022 at Citama Hospital which was returned by the BPJS verifier. The population in this study is the entire inpatient medical record file of the BPJS patient inpatient care unit which was returned by the BPJS verifier from January to May 2022 at Citama Hospital. Data Collection of data taken both qualitative data and quantitative data will support each other. In this study, data collection used several ways, namely: a) Questionnaire, which is data collection using questions asked to respondents. Scale using the Likert scale. b) Interview, is a meeting of two people to exchange information and ideas through question and answer, so that meaning can be constructed in a particular topic. c) Documentation, a method of collecting data obtained by viewing or analyzing documents created by the subject himself or others on the subject.

In this study, a quantitative approach was used. Research with a quantitative approach emphasizes its analysis on numerical data (numbers) processed with statistical methods. Basically, a quantitative approach is carried out on inferential research (in order to test the hypothesis) and leans the conclusions of the results on a probability of error in the rejection of the hypothesis nil. With quantitative methods, it will obtain the results of the significance of group differences or relationships between the variables studied. In general, quantitative research is a large sample research.

RESULTS AND CONCLUSIONS

RESULTS

Reducing Sugar Levels

The test results for reducing sugar levels in breadfruit flour are presented in Table 1.

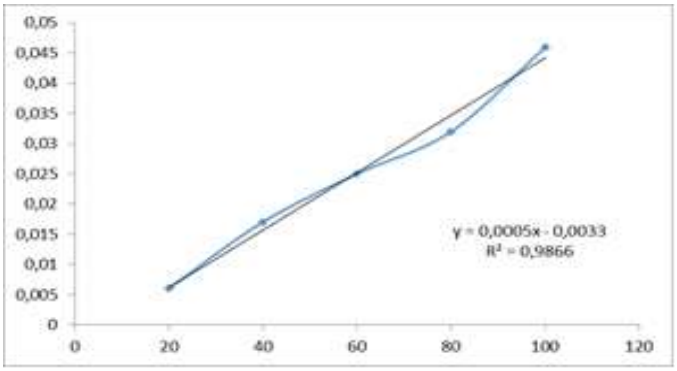
Table 1. Standard absorbance

Const. Standard (ppm)	Absorbance
20	0,006

40	0,017
60	0,025
80	0,032
100	0,046

Based on the results in Table 1, a standard calibration curve of reducing sugar is obtained as shown in Figure 1.

Figure 1. Standard reducing sugar calibration curve



From Figure 1 it can be seen that the regression equation of the calibration curve with the regression equation y = 0.0005x + 0.0033 with a correlation coefficient R^2 = 0.9866. The R value obtained in this study is close to 1, which means there is a correlation between absorbance and concentration. From the calibration curve, the reducing sugar content of breadfruit flour can be calculated. The calculation results obtained reducing sugar content of breadfruit flour of 3.26%. From these results it can be seen that the reducing sugar content in breadfruit flour is very low so that breadfruit is very safe for consumption by the public, especially those suffering from diabetes mellitus.

Amylose Levels

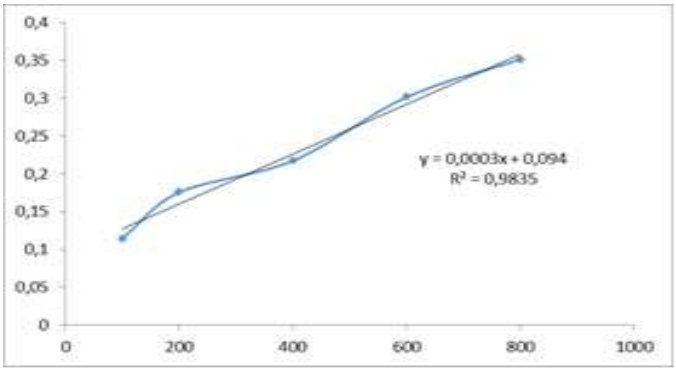
Test results for amylose levels in breadfruit flour are presented in Table 2.

Table 2. Test results for amylose content of standard solutions

Const. Standard (ppm)	Absorbance
100 ppm	0,115
200 ppm	0,176
400 ppm	0,218
600 ppm	0,302
Starch standard	0,352
Breadfruit flour sample	0,152

Based on the results in Table 2, the amylose standard calibration curve is obtained as shown in Figure 2.

Figure 2. Standard amylose calibration curve



From Figure 2 it can be seen that the regression equation of the calibration curve with the regression equation y = 0.0003x + 0.0094 with a correlation coefficient R2 = 0.9835. The R value is close to 1 which means there is a correlation between absorbance and concentration. From the calibration curve, it is possible to calculate the reducing sugar content of breadfruit flour and obtain a reducing sugar content of 19.3%. The amylose content in breadfruit flour is still relatively low when compared to the amylose content in several other food ingredients. Comparison of starch content in several food ingredients is presented in Table 3.

Table 3. Comparison of amylose content in several food ingredients

Type of food ingredient	Amylose content (%)
Mango	20,0
Banana flour	93,50
Purple sweet potato	19,61
Sweet potato paste	35,64
Breadfruit flour	19,3

Based on the results in Table 3 it can be seen that the amylose content in breadfruit flour is almost the same as in purple sweet potato. The low amylose content found in this study indicates that breadfruit flour is very good and safe for consumption by people with diabetes mellitus.

Blood Sugar Levels

The results of tests on blood sugar levels (KGD) in the normal control group (KN), the negative control group (K-), the positive control group (K+), and the STZ-induced group of mice and were given breadfruit flour can be seen in Table 4.

Table 4. Results of KGD measurements

Treatment	Blood Sugar Level (mg/dl) ± SD		
	Day 0	Day 3	Day 10

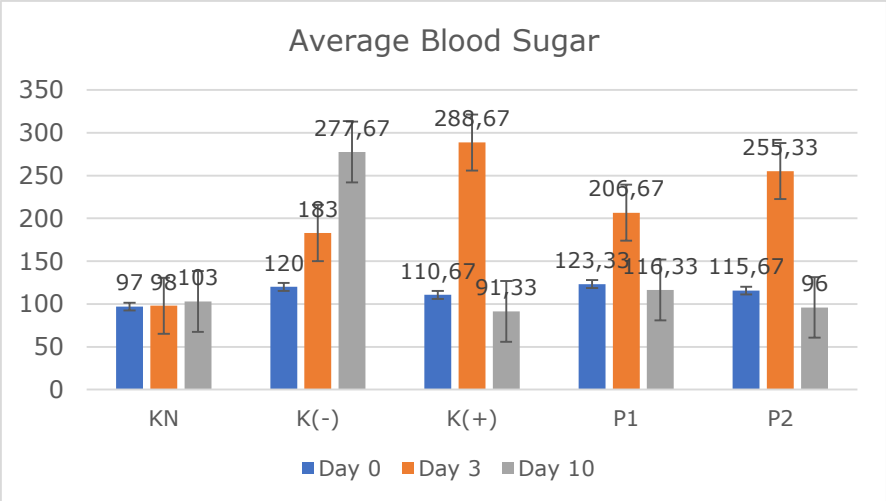
KN	97,00± 21,93	98,00 + 12,67	103 ± 13,53[a]
K (-)	120,00±15,71	183,00±3,61	277,67±10,51[b]
K (+)	110,67±9,29	288,67±17,95	91,33 ± 9,45[c]
P1	123,33±43,29	206,67±5,86	116,33 ± 3,51[c]
P2	115,67±24,83	255,33±15,70	96,00 ± 18,36[c]
Total	113,33±23,73	186,73±104,32	136,87±74,10

Description : Superscripts with the same letters are not significantly different (P > 0.05).

Based on the results in Table 4, it shows that the average of the normal mice group glucose at the first measurement was 97.00 ± 21.93 mg/dl, the average of the K(-) group was 120.00 ± 15.71 mg/dl, the K (+) group averaged KGD of 110.67 ± 9.29 mg/dl and the P1 and P2 groups respectively 123.33 ± 43.29 and 115.67 ± 24.83 mg/dl. In the K(-), K(+), P1 and P2 groups, they were induced with STZ and checked the KGD on day 3 after induction and the measurement results showed that the K(-) KGD group had an increase of 183.00 ± 3.61 mg /dl, in the K(+) group of KGD it was 288.67 ± 17.95 mg/dl, in P1 KGD it was 206.67 ± 5.86 mg/dl and in P2 it was 255.33 ± 15.70 mg/dl. After that, the K(+) group was given metformin, P1 was given 5 g of breadfruit flour and P2 was given 10 g.

On the 10th day of measurement, the KGD in KN was 103 ± 13.53 mg/dl, K(-) was 277.67 ± 10.51 mg/dl, K(+) was 91.33 ± 9.45 mg/dl , P1 was 116.33 ± 3.51 mg/dl and P2 was 96.00 ± 18.36 mg/dl. The results showed that the treatment of breadfruit flour could affect the decrease in STZ-induced KGD in mice. The results in Table 6 can be seen in Figure 3.

Figure 3. Histogram of Average Blood Sugar Levels



Based on the results of the Analysis of Variance (ANOVA) using the SPSS 16 program, it was shown that breadfruit flour treatment had an effect on reducing blood sugar levels in mice with diabetes mellitus (sig <0.05) where the calculated F value was

126.316 with an F probability of 0.000. The results of further tests using the Least Significant Difference Test (LSD) at a significant level of 0.05% showed that there was a significant effect on the average blood sugar levels in the KN and K- group of mice but there was no significant effect between K +, P1 and P2.

DISCUSSION

Reducing Sugar Levels

Based on the results of the study, it can be seen that the reducing sugar content in breadfruit flour is 3.26%. Reducing sugar levels obtained in this study were very low. This indicates that the quality of sugar in breadfruit flour is very good. Who argued that the lower the reducing sugar content, the better the quality of the sugar, conversely, the higher the reducing sugar content, the lower the quality of the sugar.

States that reducing sugars (glucose and fructose) correlate with the amount of sugar and sweetness in a product. In general, reducing sugars are produced through the process of breaking down carbohydrates (starch) by the enzyme amylase into sugars. The sugars produced from this decomposition process are glucose, sucrose and fructose (Zhang et al., 2002).

Reducing sugar content also correlates with the glycemic index (GI) of a food ingredient and product where low reducing sugar levels often give a less sweet taste to food ingredients or products indicating a low GI. The GI value of a carbohydrate food source shows how much blood sugar levels increase after consuming these carbohydrates which is expressed in the percentage response to a portion of carbohydrates which is equivalent to a standard reference of 50 g of glucose. The glycemic index of foodstuffs is divided into three categories: foodstuffs with a low glycemic index (GI < 55), foodstuffs with a moderate glycemic index (55 ≤IG ≤70), and foodstuffs with a high glycemic index (GI > 70) (Pereira et al., 2014).

Based on the existing reducing sugar levels, it can be concluded that the GI value of breadfruit flour is very low, so it is very safe for consumption for people with diabetes mellitus. Breadfruit has a GI of around 23-60. Also added that breadfruit has a glycemic index or a number that shows the potential to increase blood glucose from low carbohydrates so that it can play a role in controlling blood sugar levels.

Amylose Levels

Amylose is a straight chain polymer of glucose connected by α-(1,4)-glycosidic bonds. The higher amylose content causes slower digestion because amylose is a glucose polymer that has an unbranched structure a more crystalline structure with more extensive hydrogen bonds) (Behall & Hallfrisch, 2002).

Amylose content is often used to predict starch digestibility, glycemic index of blood glucose response and insulin response to rice. Breadfruit flour has a low amylose content which tends to have low hypoglycemic activity as well. The results of a study which used 3 types of feed with different levels of amylose (Treatment With High Amylose Content (TAH); Treatment With Intermediate Amylose Content (TAI);

Treatment With Low Amylose Content (TAL) on digestibility observed in mice showed that feeds given with high amylose content (TAH) were digested more slowly. This is indicated by the value of Apparent Starch Digestibility (ASD) which is lower than TAI and TAL.

Starch granules that contain more amylose have a more crystalline structure caused by intensive hydrogen bonds. Thus amylose is difficult to gelatinize and difficult to digest. In addition, amylose is also easy to combine and crystallize so that it easily undergoes retrogradation which is difficult to digest (Widowati, 2009).

Blood Sugar Levels

In general, the induction of streptozotocin in mice in this study led to an increase in blood sugar levels. This can be seen by the high blood sugar levels in the K-, K+, P1 and P2 groups of mice. There was an increase in blood sugar levels in the study because streptozotocin was selective, causing damage to pancreatic ß cells (Pathak et al., 2008). Damage to pancreatic β cells due to streptozotocin occurs through several processes simultaneously, namely through the oxidation of sulfidyl groups and the formation of free radicals. The mechanism of action of streptozotocin results in damage to pancreatic β-cells primarily attacking cellular compounds containing sulfhydryl groups, amino acids cysteine and proteins that bind to SH groups (including enzymes containing SH groups). Streptozotocin reacts with two SH groups that bind to the sides of proteins or amino acids to form disulfide bonds, thereby inactivating proteins which result in impaired protein function (Pathak et al., 2008).

The average blood sugar level in the K+ group of mice (treated with metformin) was lower than that of P1 and P2. This is because metformin can lower blood glucose levels where insulin is able to control post prandial glucose while metformin controls fasting blood glucose so that blood glucose is controlled at all times. Metformin helps the liver to be more sensitive to insulin and insulin to work better.

The results in table 4 also show that in the group of mice that were given breadfruit flour 5 gr (P1) and 10 gr (P2) there was a decrease in blood sugar levels but it was still higher when compared to K+. The decrease in blood sugar levels in groups P1 and P2 was due to breadfruit flour containing very low levels of reducing sugar and amylose. Low reducing sugar levels can help diabetics limit the consumption of sugar in their food Sifat Kimia Dan Kesukaan Cookies Yang Disubstitusi Dengan Tepung Uwi Ungu (Dioscorea Alata L.).

Amylose can slow the absorption of glucose from the digestive system (small intestine) into the blood. Delaying the absorption of glucose into the blood results in the rate of rise of blood glucose being inhibited so as to lower blood glucose levels in the body. In addition, amylose has an unbranched and compact structure compared to amylopectin so that it takes longer to digest and the increase in blood glucose is lower than foods high in amylopectin (Ravika et al., 2022). Showed that the glycemic response decreased after consuming foods containing 45% amylose and 55% amylopectin compared to foods containing 100% amylopectin.

CONCLUSION

Reducing sugar and amylose levels in breadfruit flour are still very low, where the reducing sugar content in breadfruit tubing is 3.26% and the amylose content in breadfruit flour is 19.3%. Breadfruit flour can reduce blood sugar levels in mice with diabetes mellitus. The effective dose of breadfruit flour in lowering blood sugar levels is 10 g/kg BW.

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