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Effectiveness of synbiotic yogurt made from *pisang batu* (*musa balbisiana*) flour on blood glucose levels and cholesterol levels in type 2 diabetes mellitus patients

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is characterized by high blood sugar due to problems with insulin secretion or action. Patients with diabetes often experience dyslipidemia, affecting cholesterol levels. Synbiotic yogurt fermented with Lactobacillus bulgaricus and Streptococcus thermophilus can lower cholesterol through short-chain fatty acids (SCFAs) production. Adding *Pisang Batu* (*Musa balbisiana*) flour, a source of fructo-oligosaccharides (FOS), enhances propionic acid in the yogurt, which may improve insulin resistance in metabolic syndrome.

Objective: to determine the effect of synbiotic yogurt with banana flour (*M. balbisiana*) on blood glucose levels and cholesterol levels in patients with type 2 diabetes mellitus who are outpatients at the KMRT Wongsonegoro Regional Hospital.

Materials and Methods: A Randomized Controlled Trial (RCT) with a pretest–posttest control group design was conducted on 47 outpatients with type 2 diabetes mellitus at KMRT Wongsonegoro Hospital. The study consisted of 24 patients in the treatment group who were given 300 ml of synbiotic yogurt per day for 4 weeks and 23 patients in the control group. Data analysis used the paired t test.

Results: Results showed a significant reduction in blood glucose in the treatment group (8.72 ± 23.51 mg/dL, p = 0.000), while the control group had a slight increase (-3.35 ± 17.20 mg/dL, p = 0.005). The difference between groups in glucose reduction was also significant (11.07 ± 7.08 mg/dL, p = 0.000). However, there was no significant difference in cholesterol levels between the groups (p = 0.224).

Conclusion: giving 300 ml of synbiotic yogurt with banana flour every day for 4 weeks was effective in reducing the patient's blood glucose levels but was not effective in reducing cholesterol levels.

Keywords *: Blood glucose; cholesterol; diabetes mellitus; pisang batu (Musa balbisiana) flour*

BACKGROUND

The incidence of diabetes based on data from the *International Diabetes Federation* (IDF) in 2021 is estimated at 537 million people aged 20-79 years in the world. Diabetes sufferers are estimated to increase to 643 million in 2030 and 783 million in 2045. Indonesia is ranked 5th out of 10 countries with the largest number of diabetes sufferers, which is 19.5 million.[1] The results of the Basic Health Research (Riskesdas) in Indonesia stated a significant increase in the prevalence of diabetes, namely from 6.9% in 2013 to 8.5% in 2018.[2] Diabetes mellitus patients at KMRT Wongsonegoro Hospital experienced an increase in cases, with 335 patients recorded from January to December 2023.

Diabetes Mellitus (DM) is a group of metabolic diseases characterized by hyperglycemia, disorders of insulin secretion, insulin action, or both.[3] According to the International Diabetes Federation, diabetes mellitus (DM) is a chronic disease characterized by increased blood glucose levels which can occur because the body cannot produce the hormone insulin or cannot use the hormone insulin effectively.[1]

Type II diabetes mellitus can be caused by genetic factors, gender, age, and history of diabetes. In addition, type II diabetes mellitus is also often referred to as lifestyle diabetes because it is caused by unhealthy lifestyles such as obesity, lack of physical activity.[4] Non-pharmacological management helps reduce blood glucose levels and complications of metabolic syndrome by utilizing functional foods such as prebiotics and probiotics.

Probiotics are living microorganisms that, when given in sufficient quantities, can be beneficial to other organisms or their hosts).[5] Probiotics stimulate the growth and activity of bacteria that are beneficial to the body.[6] Probiotics can be found in various products such as yogurt, milk, tempeh, kefir, and others. Bacteria play a role in maintaining intestinal microflora to improve insulin sensitivity so that blood glucose levels can be controlled.[7]

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Yogurt is a fermented milk product that is currently gaining popularity. According to an analysis by Spire Research and Consulting, yogurt accounted for 28% of total dairy product consumption in Indonesia in 2022.[8] Not only is yogurt popular, it also offers numerous health benefits due to its probiotic content. Probiotics are living microorganisms that provide health benefits to their human hosts when consumed in adequate amounts and can help maintain the balance of intestinal microflora and support a healthy digestive system.[9]

Research on rats induced by alloxan showed a decrease in blood glucose levels from 190.69 ±)13.8 mg dL^{1-} on day 20 to 182.84 ± 15.02 mg dL^{1-} on day 40 after administration of probiotics 3,6 mL 200 g^{1-} body weight (BW) of mice per day. The growth of probiotics is influenced by prebiotics which provide specific substrates for the fermentation process. Prebiotics as fermented dietary fiber provide changes in the activity of intestinal microflora.[10]

Bananas contain prebiotics which are easily found in Indonesia. *Pisang Batu (Musa balbisiana)* as type of plantain banana, is more suitable for processing into flour. *Pisang Batu (Musa balbisiana)* contains several prebiotic components, including fructooligosaccharides (FOS) at 427.03 mg mL^{-1}, resistant starch at 39.35%, and inulin at 1 g per 100 g of banana weight.[10] Fermented prebiotic FOS produces short chain fatty acids (SCFA) which suppress glucose production and improve insulin sensitivity. Resistant starch and inulin also produce SCFA.[11] Therefore, this study aims to analyze the effect of Yogurt Synbiotic *Pisang Batu (Musa balbisiana)* on fasting blood glucose levels in Diabetes Mellitus patients.

MATERIALS AND METHODS

This research used a true experimental method with a pretest–posttest control group design. The sample was 30 patients as control and 30 patients as treatment. Data analysis used the Paired t test. The inclusion criteria were patients aged 35–65 years, not receiving insulin therapy, and having a medical diagnosis of type 2 diabetes mellitus with dyslipidemia. The exclusion criteria were patients who experienced diarrhea during the study, had weight loss of more than 10%, were pregnant or breastfeeding, had complications of liver or kidney disease, did not complete the posttest, or died during the study period. The treatment group was given 150 ml of synbiotic yogurt made from kefir and *Pisang Batu (Musa balbisiana)* flour twice a day for four weeks.[10] Two weeks before the start of the study, all patients were not to consume probiotic fermented milk and any probiotic foods. During the four weeks of intervention. Patients were asked not to change their diet, lifestyle, consumption of other vitamin and mineral supplements, medication and traditional medicine as additional therapy during the study during the study period. In addition, patients were asked to inform the researchers, if there were any changes in treatment during the intervention. Dietary intake was monitored using periodic 24-hour food recall. Compliance with yogurt consumption was assessed through daily consumption records and the return of empty yogurt containers. Follow-up reminders were also provided to ensure adherence to the intervention. Macromineral intake for 3 days was analyzed by average macromineral intake, data on patient characteristics was obtained using a questionnaire. Body weight was measured using a Seca scale with an accuracy of 0.1 kg using light clothing and without shoes. Body height was measured using a stadiometer (Seca) with an accuracy of 0.1 cm. Body mass index (BMI) was calculated as body weight in kilograms divided by the square of body height in meters (kg/m2). Fasting blood samples were taken for biochemical analysis from the antecubital vein. Taken from patients fasting 10 to 12 hours overnight and centrifuged within 30-45 minutes after collection and serum stored at -70°C Serum concentrations of fasting blood glucose (FBS), total cholesterol (TC) were determined using kits and enzymatic methods with Auto - analyzer Bio -System (Authoanalyzer, BS-200, MINDRAY chemical analyzer). Low-density lipoprotein cholesterol (LDL-C) was calculated according to the FriedeWald formula procedure.

This study was conducted after obtaining ethical clearance number 060/Kom.EtikRSWN/VI/2024 dated June 24, 2024, from the Research Ethics Committee of K.R.M.T Wongsonegoro Hospital, Semarang City. Data were analyzed using appropriate statistical methods to evaluate the effect of synbiotic yogurt on fasting blood glucose and cholesterol levels in patients with type 2 diabetes mellitus.

RESULTS

The characteristics of participants with Type 2 Diabetes Mellitus at KRMT Wongsonegoro Hospital were analyzed to determine the comparability of the treatment and control groups before the intervention. Several variables, including demographic characteristics, lifestyle factors, compliance with synbiotic yogurt consumption, macronutrient intake, and biochemical parameters, were evaluated to provide an overview of the study population and to assess changes observed during the intervention period.

Table 1. Distribution of Characteristics of Type 2 Diabetes Mellitus Patients at KRMT Wongsonegoro Hospital

Variable	Treatment Group		Control Group		p-value
	N = 24	%	N = 23	%	
Sex					
Men	6	25%	9	39.1%	0.252
Women	18	75%	14	60.9%	
Age					
<60 years old	15	62.5%	13	56.5%	0.351
≥ 60 years old	9	37.5%	10	43.5%	
Work					
Unemployment	22	91.7%	20	86.9%	0.366
Employment	2	6.7%	3	13.1%	

Characteristics of the subjects in the study included gender, age, and employment status (Table 1). The results of the chi-square analysis showed that there were no differences in characteristics between the treatment group and the control group ($p>0.05$). So it can be said that there were no differences between the two groups at the start of the study (Table 1).

Table 2. Distribution of Smoking Habits and Activities of Type 2 Diabetes Mellitus Patients at KRMT Wongsonegoro Hospital

Variable	Treatment Group		Control Group	
	N = 24	%	N= 23	%
Smoking Habit				
Yes	2	8.3	3	13.0
No	22	91.7	20	87.0
Total	24	100.0	23	100.0
Physical Activity				
Yes	14	58.3	12	52.2
No	10	41.7	11	47.8
Total	24	100.0	23	100.0

Table 2 presents the distribution of smoking habits and physical activity among patients with Type 2 Diabetes Mellitus in the treatment and control groups at KRMT Wongsonegoro Hospital. Most participants in both groups did not have a smoking habit, accounting for 91.7% in the treatment group and 87% in the control group. Regarding physical activity, more than half of the patients in both groups reported engaging in physical activity, with 58.3% in the treatment group and 52.2% in the control group. Overall, the distribution of smoking habits and physical activity was relatively similar between the two groups.

Table 3. Distribution of Compliance with Synbiotic Yogurt Consumption for Type 2 Diabetes Mellitus Patients at KRMT Wongsonegoro Hospital

Variable	Treatment Group		Control Group	
	N = 24	%	N= 23	%
Yoghurt Intake (%)				
Enough (>80%)	23	95.8%	22	95.6%
Not Enough (<80%)	1	4.2%	1	4.4%
Total	24	100.0%	23	100.0%

Table 3 shows that most respondents had good compliance with yogurt consumption. In the treatment group, 23 respondents (95.8%) had adequate intake (>80%), while only 1 respondent (4.2%) had inadequate intake (<80%). Similarly, in the control group, 22 respondents (95.6%) had adequate intake and 1 respondent (4.4%) had inadequate intake. Overall, these results indicate that the majority of respondents in both groups complied well with the synbiotic yogurt consumption during the study period.

Table 4. Macromineral Intake at the end of the Study

Variable	Treatment Group *Mean ±SD*	Control Group *Mean ±SD*	*p*
Energy (kkal)	1049.84 ± 308.42	1044.78 ± 284.90	0.973
Protein (g)	29.95 (23.65)	29.2 (12.15)	0.66
Fat (g)	31.9 (20.25)	34.9 (14.55)	0.558
Carbohydrate (g)	148.29 ± 49.39	150.81 ± 43.94	0.887

Information: Δ=delta Sd=standard deviation p =value

Table 4 among patients with type 2 diabetes mellitus at K.R.M.T Wongsonegoro Hospital shows that the average energy intake in the treatment group was 1049.84 ± 308.42 kcal, while in the control group it was 1044.78 ± 284.90 kcal, with no significant difference between the two groups (p=0.973). Protein intake in the treatment group was 29.95 g and in the control group 29.2 g (p=0.66). Fat intake was 31.9 g in the treatment group and 34.9 g in the control group (p=0.558). Meanwhile, carbohydrate intake was 148.29 ± 49.39 g in the treatment group and 150.81 ± 43.94 g in the control group (p=0.887). Overall, there were no significant differences in macronutrient intake between the treatment and control groups at the end of the study.

Table 5. Fasting blood glucose levels of T2 DM patients at R KRMT Wongsonegoro

Variable	Treatment Group *Mean ±SD*	Control Group *Mean ±SD*	*p*
GDP Pre (mg/dL)	211.42 ± 102.54	182.52 ± 72.62	0.273
GDP Post (mg/dL)	174.17 ± 105.50	196.48 ± 84.92	0.430
Δ=delta	−37.25 ± 63.55	13.96 ± 88.03	0.027

Information: Δ=delta Sd=standard deviation p =value

Table 5 among patients with type 2 diabetes mellitus at K.R.M.T Wongsonegoro Hospital shows that the mean fasting blood glucose level in the treatment group decreased from 211.42 ± 102.54 mg/dL before the intervention to 174.17 ± 105.50 mg/dL after the intervention. In contrast, the control group showed an increase from 182.52 ± 72.62 mg/dL to 196.48 ± 84.92 mg/dL. The mean change (Δ) in fasting blood glucose levels was −37.25 ± 63.55 mg/dL in the treatment group and 13.96 ± 88.03 mg/dL in the control group. Statistical analysis indicated that the difference in changes between the two groups was significant (p = 0.027), indicating that the intervention had a significant effect on reducing fasting blood glucose levels.

Table 6. Total Chlorestol Levels at the end of the Study

Variable	Treatment Group *Mean ±SD*	Control Group *Mean ±SD*	*p*
Initial-Final Total Chlorestol Levels	167 – 209.15 mg/dL	158.43 – 189.29 mg/dL	0.52
Δ=delta	42.73 mg/dL	30.72 mg/dL	0.67

Information: Δ=delta Sd=standard deviation p =value

Table 6 among patients with type 2 diabetes mellitus at K.R.M.T Wongsonegoro Hospital shows that the mean total cholesterol levels in the treatment group increased from 167 mg/dL at baseline to 209.15 mg/dL at the end of the study. In the control group, the mean total cholesterol levels increased from 158.43 mg/dL to 189.29 mg/dL. The change in total cholesterol levels (Δ) was 42.73 mg/dL in the treatment group and 30.72 mg/dL in the control group. However, the difference between the two groups was not statistically significant (p=0.67).

DISCUSSION

The results of this study showed that most of the subjects were 60 years old. This is in line with research by Rif'at et al. where metabolic syndrome occurs more often at the age of 40 years and over.[12] Other studies also show that in the 60-69 age group, metabolic syndrome is most common, with most respondents at that age being retired, indicating a prevalence that tends to increase with age.[13] As we age, the sensitivity of the pancreas to produce insulin decreases, thereby increasing the risk of disease complications.

According to PERKENI, increasing age is associated with a higher risk of developing type 2 diabetes mellitus, particularly in individuals aged >45 years. This condition is related to the aging process, which leads to various anatomical, physiological, and biochemical changes, including increased insulin resistance.[14] In addition, aging is associated with decreased pancreatic β-cell function and reduced glucose tolerance, which contribute to impaired insulin secretion and glucose metabolism. These changes increase the risk of

hyperglycemia and the development of type 2 diabetes mellitus in older adults. Therefore, age is considered an important non-modifiable risk factor for type 2 diabetes mellitus.

This study was attended by mostly women, in accordance with previous research where the prevalence of metabolic syndrome was more common in women.[15] Prevalence of type 2 diabetes increases in both men and women, but women are typically diagnosed at an older age with higher body fat mass, particularly after menopause due to the release of hormones that promote visceral fat accumulation. Women also exhibit a greater burden of risk factors such as obesity and hypertension at diagnosis. BMI is less accurate in assessing risk in women than waist circumference. Psychosocial factors such as stress also have a greater impact on women. The risk of cardiovascular complications and death from type 2 diabetes is higher in women than in men.[16]

Most of the respondents in this study were non-smokers, in line with research by Rahim et al. which reported that 80% of samples with metabolic syndrome were non-smokers. Eighty percent of the sample were non-smokers.[17] The physical activity level of some of the subjects in this study was moderate, while others were light. According Khair and Harvianto, lack of physical activity is closely related to the incidence of metabolic syndrome.[18] On the other hand, physical activity can change risk factors for metabolic syndrome, especially by increasing insulin sensitivity.

Compliance with the consumption of synbiotic yogurt for Type 2 Diabetes Mellitus patients at KRMT Wongsonegoro Hospital in the treatment group who were given 150 ml of synbiotic yogurt 2 times every day which was consumed as a morning and afternoon snack for 4 consecutive weeks. The average consumption of synbiotic yoghurt in the treatment group for 4 weeks could use up 100% of the synbiotic yoghurt given. However, in the 3rd week there was a decrease in the average consumption of synbiotic yogurt, this happened because several respondents stated that they forgot to finish the synbiotic yogurt. In the 4th week there was an increase because respondents were reminded to finish the synbiotic yogurt that had been given. Subject compliance in consuming synbiotic yogurt was classified as good, namely 95.8% and there was no significant difference in the two groups (Table 3).

Carbohydrate intake is a predictor for metabolic syndrome in respondents aged 25 years and over. Controlling carbohydrate intake in women is a priority for metabolic syndrome control programs in society. The predictors for the incidence of metabolic syndrome in women are 4.78 times higher risk compared to men and carbohydrate consumption is 2.99 times.[19] The recommended energy content for snack foods is 10–20% of the total daily requirement.[20] Compared with the Nutrition Label Reference (ALG) for the general population, this yogurt provided 10.9% of the recommended daily energy intake, indicating that it could be considered an appropriate snack.

Yogurt contains protein sources such as liquid milk and skim milk. The heating process can cause denaturation, a change or modification in the structure of protein molecules, where the protein will experience physical changes and biological activity, resulting in a decrease in enzyme activity, which can affect the protein's nutritional value.[21] Research by Darmawati et al., states that heating at temperatures of 80°C to 105°C can reduce the protein content. It can be concluded that the higher the heating temperature, the lower the protein content in the product.

This yogurt provided only 6.20% of the recommended fat requirement; therefore, it did not meet the fat contribution criteria for a snack product. This was likely due to the low fat content of the raw materials used, including low-fat UHT milk containing 1.25 g of fat per 100 g and skim milk containing 1 g of fat per 100 g. Consequently, the overall fat content of the yogurt was relatively low. However, this product may still be suitable for individuals who require a low-fat diet, such as patients with metabolic disorders or those aiming to control their fat intake. Furthermore, the relatively low fat content of the yogurt may contribute to improved dietary management in individuals with type 2 diabetes mellitus and other metabolic disorders requiring fat restriction. Therefore, synbiotic yogurt formulated with low-fat ingredients may be considered a potential functional snack alternative to support healthier nutritional intake and metabolic control.

The carbohydrate content of the yogurt was derived from lactose present in milk and from the addition of *Pisang Batu (Musa balbisiana)* flour used in the yogurt formulation. As a functional food, meeting the Nutrition Label Reference (LFR) for carbohydrates not only serves as a source of easily absorbed energy but also has the potential to support increased intestinal metabolism through the prebiotic effect of the carbohydrate source, rock banana flour, in the form of polysaccharides, which have a prebiotic effect on the product.[22]

The results of the paired t test showed that the difference in the mean blood glucose levels of the treatment group before and after the intervention was 8.72 ± 23.51 mg/dL (p = 0.000), while the control group was -3.35 ± 17.200 mg/dL (p = 0.005). The difference in decreasing glucose levels between the two groups was 11.073 ± 7.082 mg/dL (p = 0.000), which shows a significant difference.

Consuming milk ≤14 times a week can increase the risk of T2DM. Dairy products that are protective against type 2 diabetes mellitus (T2DM) are fermented products, namely yogurt and yogurt drinks Fildzah Badzlina and Triyanti. Bananas are one of the food products that contain prebiotics that are easily found in Indonesia. *Pisang Batu (Musa balbisiana)* is a type of plaintain banana which is better used as flour.[10] *Pisang Batu (Musa balbisiana)* themselves contain prebiotic Fructooligosaccharides (FOS) of 427.03 mg mL^{1-}, resistant starch of 39.35%, and inulin of 1 g 100 g. *Pisang Batu* synbiotic yogurt may be an effective intervention for reducing fasting blood glucose and cholesterol in patients with type 2 diabetes melitus. The yogurt contains prebiotics, such as inulin and fructooligosaccharides (FOS) from *Pisang Batu (Musa balbisiana)* flour, which improve gut microbiota composition and enhance glucose metabolism and insulin sensitivity. In addition, probiotics from fermented milk can help lower cholesterol by binding intestinal cholesterol, producing short-chain fatty acids, and modulating bile acid metabolism. The combination of prebiotics and probiotics provides a synergistic effect on glycemic and lipid control, supporting its use as a functional dietary intervention for diabetic patients.

The results of the analysis showed no significant difference in total cholesterol levels before and after the intervention in the control group and treatment group ($p>0.05$). However, in both groups there was a significant increase in cholesterol levels ($p<0.05$). The increase in total cholesterol levels in the control group was 42.73 mg/dL (167 - 209.15 mg/dL) and in the treatment group was 30.72 mg/dL (158.43 - 189.29 mg/dL). There was an increase in cholesterol levels in the treatment group and the control group in the results of this study, although the results of the fat intake analysis did not have a relationship p 0.558, but the source of cholesterol was the same from food and from biosynthesis, about half of the body's cholesterol comes from the synthesis process (about 700 mg/day) and the rest is obtained from food. The liver and intestines each produce about 100% of the total synthesis in humans. Almost all tissues with nucleated cells are capable of synthesizing cholesterol, a process that occurs in the endoplasmic reticulum and cytosol.[23]

This study has several limitations. The relatively small sample size and the recruitment of participants from a single hospital may limit the generalizability of the findings. Intervention period of four weeks may not have been sufficient to observe long-term effects, particularly on cholesterol levels. Dietary intake and lifestyle factors were monitored using self-reported methods, which may introduce reporting bias. In addition, this study only assessed fasting blood glucose and total cholesterol, without evaluating other metabolic indicators such as HbA1c, LDL, HDL, and triglycerides.

CONCLUSION

The administration of 300 ml of synbiotic yogurt made from *Pisang Batu (Musa balbisiana)* flour each day for four weeks was effective in reducing patients blood glucose levels but was not effective in lowering cholesterol levels. Based on these findings, yogurt can generally be considered an alternative snack for individuals with type 2 diabetes mellitus due to its potential effect in reducing fasting blood glucose levels.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to this study.

DECLARATION USE AI

The authors confirm that no Artificial Intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript.

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