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Hypoglycemic effect of *Musa sapientum l*. peel biscuits in Maros, Indonesia

Efecto hipoglicemiante de las galletas de cáscara de *Musa sapientum l*. en Maros, Indonesia

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SUMMARY

Background: *Diabetes mellitus is a chronic metabolic disease characterized by increased blood sugar levels. The treatment of diabetic patients is carried out using non-pharmacological and pharmacological treatments. Banana (Musa sapientum L.) peels are known to have pharmacological effects, such as antioxidant and hypoglycemic.* **Objective:** *This study aims to determine the effect of banana (Musa sapientum L.) peel biscuits administration on blood sugar levels in diabetes mellitus patients, providing a potential non-pharmacological treatment option.* **Methods:** *It is an experimental research with a pre-posttest and control group design. Sampling used a purposive sampling technique, with a sample size of 40 diabetic patients, all taking metformin (20 intervention, 20 control groups). Data analysis was performed using the Wilcoxon test.* **Results:** *The study revealed a significant reduction in blood sugar levels (an average of -10.4 %) in diabetes mellitus patients before and after banana (Musa sapientum L.) peel biscuits and metformin administration when compared with the control group receiving only metformin as antidiabetic treatment (-1.8 %). This reduction in blood sugar levels is convincing evidence of the potential of banana peel biscuits as a non-pharmacological treatment option.* **Conclusion:** *Banana (Musa sapientum L.) peel biscuits are coadjuvant in controlling blood sugar levels in patients with diabetes mellitus, offering a practical and potentially effective treatment option.*

Keywords: *Banana peel, biscuits, blood sugar levels, diabetes mellitus; Musa sapientum L.*

RESUMEN

Antecedentes: *La diabetes mellitus es una enfermedad metabólica crónica caracterizada por un aumento de los niveles de azúcar en sangre. El tratamiento de los pacientes diabéticos se realiza mediante tratamientos farmacológicos y no farmacológicos. Se sabe que las cáscaras de plátano (Musa sapientum L.) tienen efectos farmacológicos, como antioxidantes e hipoglucemiantes.* **Objetivo:** *Este estudio tiene como objetivo determinar el efecto de la administración de*

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galletas de cáscara de plátano (Musa sapientum L.) sobre los niveles de azúcar en sangre en pacientes con diabetes mellitus, proporcionando una posible opción de tratamiento no farmacológico. **Métodos:** *Es una investigación experimental con un diseño pre-postest y grupo control. El muestreo utilizó una técnica de muestreo intencional, con un tamaño de muestra de 40 pacientes diabéticos, todos tomando metformina (20 grupos de intervención, 20 grupos de control). El análisis de los datos se realizó mediante la prueba de Wilcoxon*. **Resultados:** *El estudio reveló una reducción significativa en los niveles de azúcar en sangre (un promedio de -10,4 %) en pacientes con diabetes mellitus antes y después de la administración de galletas con cáscara de plátano (Musa sapientum L.) y metformina, en comparación con el grupo de control que recibió solo metformina como tratamiento antidiabético (-1,8 %). Esta reducción de los niveles de azúcar en sangre es una prueba convincente del potencial de las galletas de cáscara de plátano como opción de tratamiento no farmacológico*. **Conclusión:** *Las galletas de cáscara de plátano (Musa sapientum L.) son coadyuvantes en el control de los niveles de azúcar en sangre en pacientes con diabetes mellitus, ofreciendo una opción de tratamiento práctica y potencialmente efectiva*.

Palabras clave: *Cáscara de plátano, galletas, niveles de azúcar en sangre, diabetes mellitus, Musa sapientum L.*

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disease characterized by elevated blood glucose levels; it may be due to impaired insulin secretion, resistance to peripheral actions of insulin, or both. Over time, this leads to severe damage to many of the body's systems, especially the nerves, blood vessels, heart, eyes, and kidneys (1). Data from the International Diabetes Federation (IDF) states that globally, the number of people with diabetes mellitus is found in people aged 20-79 years in several countries in the world. Indonesia is in the sixth category with the highest number of people with diabetes in the world after China, India, the United States, Brazil, and Mexico, being the country in Southeast Asia that is included in the list of 10 countries with the highest number of sufferers (2). The results of Basic Health Research (Riskesdas) in Indonesia reported that there was a significant increase in the prevalence of diabetes, from 6.9 % in 2013 to 8.5 % in 2018 (3).

The increasing prevalence of diabetes mellitus has made many researchers interested in developing anti-diabetes mellitus drugs. There have been many oral hypoglycaemic drugs that are effective in reducing high blood sugar levels, but the complications caused by diabetes mellitus have not been well prevented, so efforts are still needed to find new drugs with physiological anti-diabetic abilities that are targeted, safe, and readily available or economical (4). Medical treatment in diabetes patients is divided into two groups: non-pharmacological treatment and pharmacological treatment. Although pharmacologic agents are often prescribed to lower blood glucose levels among patients with hyperglycemia, nonpharmacologic therapies for diabetes, including dietary modifications and physical activity, play a key role in reducing microvascular complications associated with hyperglycemia. One of the non-pharmacological treatments for diabetes is traditional medicine using herbal ingredients that people with diabetes mellitus can use (5). Plants have been used in traditional medicine since antiquity, and many active metabolic products with biological significance are obtained from them.

Banana, an eatable fruit produced by some herbaceous flowering plants of the genus Musa, is one of the valuable fruits with proven pharmacological potential. The presence of phytochemical compounds, such as flavonoids and tannins, supports the role of banana fruit and peels as an antidiabetic agent. In effect, Lakshmi et al. (6) reported that ethanol extract of kepok banana peel (*Musa sapientum L.*) has the ability to reduce glucose levels by 25,5 % in Streptozotocin-induced diabetic rats (500 mg/kg). This action is possible due to the antioxidant activity of kepok banana peel of 95,1 %, higher than bay leaf, which is only 50 % (7,8).

Banana (*Musa sapientum L.*) peel has antioxidant activity calculation with a value of 97.8 %; the value is the most significant result compared to the antioxidant activity of kepok banana peel, Uli banana peel and horn banana peel (9). In addition, kepok banana peel still contains 68.9 g water, 18.5 g carbohydrate, 0.3 g protein, 2.1 g fat, 715 mg calcium, 117 mg phosphorus, 1.6 mg iron, 0.1 mg vitamin B and 17.5 mg vitamin C in 100 grams of kepok banana peel (10). This high nutritional content makes it

suitable as a substitute for wheat flour. With a high enough nutritional content, it is possible to be processed into raw materials for making food substitutes for wheat flour to reduce the amount of usage. Several studies have been conducted on banana peels to lower blood sugar levels; banana peels are processed into other forms, such as banana peel flakes, banana peel extract capsules, and banana peel cookies, which are proven to reduce blood sugar levels in rats (11-13).

Although there is evidence of the effect of banana peels on reducing blood sugar levels, there are no studies on humans using banana peel raw materials. So, it is necessary to modify food products made from low-sugar raw materials so that the food can still contribute to nutritional adequacy for people with DM. One food that is favored by almost all ages is biscuits. Biscuits can be used as functional food if the biscuits have functional properties for health, including controlling blood glucose levels and having a low glycemic index (14). Banana peel biscuits can also be added with stevia sweetener to replace cane sugar as a sweetener. Stevia leaves contain natural non-caloric sweeteners and can produce sweetness 70-400 times that of cane sugar (15).

Based on the evidence, we were interested in innovating the peel of banana (*Musa sapientum L.*) to determine the effectiveness of banana (*Musa sapientum L.)* peel on reducing blood sugar levels in patients with diabetes mellitus at Marusu and Mandai Health Center Maros Regency, Indonesia.

METHODOLOGY

This research is a quantitative study with a quasi-experimental design, using a pretest-posttest with a control group. Matching was also conducted to minimize bias by ensuring the similarity of samples in terms of gender and age group (16). Food intake was monitored during the study using the 24-hour food recall method. The dependent variable was blood sugar level. The independent variable was the administration of banana (*Musa sapientum L.*) peel biscuits. This research was conducted at the Marusu and Mandai Community Health Center, Maros Regency, in 2024.

Population and Sample

The total population was 64 individuals. Calculation of sample size was performed using the Federer formula (17). A total of 40 respondents who met the inclusion and exclusion criteria were divided into 20 treatment groups and 20 control groups. Participants from the Chronic Disease Management Program/Program Pengelolaan Penyakit Kronis (PROLANIS) of Marusu Health Center in Maros Regency who had diabetes mellitus were included in the intervention group. In contrast, participants from Mandai Health Center in Maros Regency who had diabetes mellitus were included in the control group. Sample selection was carried out through purposive sampling.

Description of cracker products

Banana (*Musa sapientum L.*) peel biscuits are made from very ripe banana (*Musa sapientum L.*) peel flour containing 80 g black flecks, 80 g wheat flour, 20 g cornflour, 10 g skimmed milk, 70 g margarine, 17 g egg yolk, 7.5 g stevia, baking soda, and vanilli (10,13).

Acceptability test (organoleptic test)

An organoleptic test evaluated the acceptability of banana *(Musa sapientum L.)* peel biscuits. This involves a hedonic test, where panelists rate their liking of the product. The test involved 25 untrained panelists aged 45 and above from Makassar, using a 3-point scale: 1 (disliked), 2 (somewhat like), and 3 (like). The collected data was manually processed and analyzed using descriptive percentage analysis to assess the panelists' reactions.

Screening of chemical content of banana (*Musa sapientum L.*) peel biscuits

Phytochemical analysis was carried out at the Makassar Health Laboratory Centre, South Sulawesi, Indonesia, with the number 24006789/LHU/BBLK-MKS/III/2024, to determine the active compounds, flavonoids, alkaloids, and

tannins in banana (*Musa sapientum L.)* peel biscuits.

Intervention

Patients fasting blood sugar levels were measured after fasting for 8-12 hours by health center staff on day 0 (before intervention), day 7 (follow-up), and measured on day 15 (after intervention). The intervention group was given banana peel (*Musa sapientum L.*) biscuits and also received metformin (500-1500 mg per day) as an antidiabetic drug; the control group received only metformin as an antidiabetic drug. Patients with diabetes mellitus were asked to respond to a questionnaire. The intervention group received banana (*Musa sapientum L.*) peel biscuits two pieces/day or 40 g/day, twice a day for 14 days at 10:00 and 16:00 (18). The experimental protocol was as follows:

Respondents from intervention and control groups completed a demographic questionnaire to determine their characteristics.

On days 0 and 7 of the study, fasting blood sugar levels were measured before the intervention. Banana (*Musa sapientum L.*) peel biscuits were consumed according to the dose. Fasting blood sugar levels were measured by taking blood samples from the respondents' fingertips using a glucometer with the EasyTouch General Check Up (GCU) brand and recording them on a blood sugar control sheet.

Food intake was measured by assessing 24-hour food recall for 14 days. Researchers directly interviewed respondents in both intervention and control groups according to guidelines validated by experts, namely Buku Foto Makanan by the Individual Food Consumption Survey Team.

Ethical considerations

This work is research with permission from the Research Ethics Commission of the Faculty of Public Health, Hasanuddin University, with number 467/UN4.14.1/TP.01.02/2024. All respondents in both intervention and control groups were given information about the purpose of the intervention and the procedures to be carried out, and the names and privacy of respondents were kept confidential. Both groups were also asked to sign a consent form before the study.

Data Analysis

Data were processed using the STATA version 14 program. This study used two analyses: univariate and bivariate. Data were tested with univariate analysis. Bivariate analysis was used to assess differences in blood sugar levels of patients with diabetes mellitus between control and intervention groups, using the Wilcoxon test to analyze significant differences. A p-value < 0.05 was considered statistically significant.

RESULTS

Organoleptic Analysis

Table 1 shows the organoleptic test results on banana (*Musa sapientum L.*) peel biscuits; the color organoleptic test scored 63 (84.0 %), with like criteria. When viewed from the criteria for like based on the percentage of color criteria, the banana (*Musa sapientum L.*) peel biscuit sample has the criteria for like with a score of 71 (94.7 %). In addition, the organoleptic test regarding smell scored the highest, 60 (80.0 %), with the criteria of like. The criteria for like is based on the percentage of smell criteria; the banana (*Musa sapientum L.*) peel biscuit sample has the criteria for like with a score of 70 (93.0 %). The organoleptic test showed that flavor had the highest 36 (48.0 %) score, according to the like criteria. When viewed from the criteria for like based on the percentage of taste criteria, the banana (*Musa sapientum L.*) peel biscuit sample has like criteria with a score of 59 (78.7 %). The organoleptic test for texture had the highest score of 42 (56.0 %), according to the criteria of like. When viewed from the like criteria based on the percentage of texture criteria, the banana (*Musa sapientum L.*) peel biscuit sample had like criteria with a score of 71 (81.3 %). The data show that most of the panelists preferred the color, smell, taste, and texture of banana (*Musa sapientum L.*) peel biscuits compared to those who did not like the color, smell, taste, and texture of banana (*Musa sapientum L.*) peel biscuits.

Table 1. Results of Organoleptic Analysis of Banana (*Musa sapientum L.*) Peel Flour and Wheat Biscuits

Criteria	Sample Value		
	n	Score	%
Color			
Like	21	63	84.0
Somewhat like	4	8	10.67
Disliked	0	0	0.0
Total	25	71	94.7 %
Smell			
Like	20	60	80.0
Somewhat like	5	10	13.0
Disliked	0	0	0.0
Total	25	70	93.0 %
Taste			
Like	12	36	48.0
Somewhat like	10	20	26.7
Disliked	3	3	4.0
Total	25	59	78.7 %
Textures			
Like	14	42	56.0
Somewhat like	8	16	21.3
Disliked	3	3	4.0
Total	25	71	81.3 %

Phytochemical Analysis

Table 2 shows that banana (*Musa sapientum L.*) peel biscuits contain active compounds. Banana (*Musa sapientum L.*) peel biscuits were positive for flavonoids at 544.3 μg/g, alkaloids at 463.8 μg/g and tannins at 738.5 μg/g. Table 2 also shows that one piece of banana (*Musa sapientum L.*) peel biscuit weighing 20 grams contains flavonoids of 10.9 mg, alkaloids of 9.3 mg, and tannins of 14.8 mg.

Table 2. Phytochemical Test Results of Banana (*Musa sapientum L.*) Peel Biscuits and Conversion of Banana (*Musa sapientum L.*) Peel Compounds/Biscuit (20 g)

Phytochemical Compounds	Test Results		Conversion Result	
	Result	Unit	Result	Unit
Flavonoid	544.3	μg/g	10.9	mg/chip
Alkaloid	463.8	μg/g	9.3	mg/chip
Tanin	738.5	μg/g	14.8	mg/chip

Characteristics of the study sample

Table 3 shows that the respondents were primarily female, with the same proportion between the intervention and control groups, 75 % each, because gender matching was done in both research groups. Respondents in this study were mainly in the ≥60 years age group with the same proportion between the intervention and control groups, namely 60 %, because age matching was also carried out in both research groups. The majority of respondents had primary school education (65 %) in the intervention group, while in the control group, the majority had high school education (35 %). Most respondents worked as housewives in the intervention group (65 %) and control group (55 %). Respondents mainly were married in the intervention group (95 %) and control group (90 %).

Table 3. Socio-Demographic Characteristics of the Sample

Variables	Intervention	Control
Gender		
Man 5	(25.0 %)	5 (25.0 %)
Woman	15 (75.0 %)	15 (75.0 %)
Age group		
45-59 years old	8 (40.0 %)	8 (40.0 %)
≥60 years old	12 (60.0 %)	12 (60.0 %)
Education		
Didn't go to school/didn't finish/primary school	2 (10.0 %)	1 (5.0 %)
Elementary school	13 (65.0 %)	6 (30.0 %)
Junior High School	1 (5.0 %)	4 (20.0 %)
Senior High School	3 (15.0 %)	7 (35.0 %)
Bachelor degree	1 (5.0 %)	2 (10.0 %)
Work		
Housewife	13 (65.0 %)	11 (55.0 %)
Private employees	5 (25.0 %)	0 (0.0 %)
Self-employed	1 (5.0 %)	2 (10.0 %
Pension 1	(5.0 %)	7 (35.0 %)
Marital status		
Marry	19 (95.0 %)	18 (90.0 %)
Single	0 (0.0 %)	2 (10.0 %)
Widow/widower	1 (5.0 %)	0 (0.0 %)
Total	20 (100.0 %)	20 (100.0 %)

Table 4 shows that most control groups had normal Body Mass Index (BMI) (75 %) as well as the intervention group (55 %). Respondents in the control group mostly did not smoke (95 %)

and the intervention group (85 %). Respondents in the intervention group mostly had no family history of diabetes mellitus (75 %), and in the control group, most had a family history of diabetes mellitus (55 %). Respondents in the intervention group mostly had diabetes mellitus for more than three years (60 %), and in the control group mostly had diabetes mellitus (50.%). Respondents in the intervention group mostly organized their meals (85 %), and in the control group (65 %). 75 % of the respondents in the intervention group mostly did physical activity, while those in the control group did not (60 %). Respondents in the control group mostly did not ingest alternative herbal treatment (60 %), while in the intervention group, 50 % did not use alternative herbal treatment. Supervision of drug swallowing in the intervention group was supervised mainly by the children (50 %); in the control group, most of the supervision of drug swallowing was carried out by spouses (45 %).

Table 4. Clinical Characteristics of the Sample

Variables	Intervention	Control
Body Mass Index (BMI)		
Normal (18.5 – 25.0)	11 (55.0 %)	15 (75.0 %)
Fat (>25.0 – 27.0)	5 (25.0 %)	3 (15.0 %)
Obesity (>27.0)	4 (20.0 %)	2 (10.0 %)
Smoking Behavior		
Yes	3 (15.0 %)	1 (5.0 %)
No	17 (85.0 %)	19 (95.0 %)
Family History		
Yes	5 (25.0 %)	11 (55.0 %)
No	15 (75.0 %)	9 (45.0 %)
Long Suffering		
<1 year	1 (5.0 %)	2 (10.0 %)
1-3 years	7 (35.0 %)	8 (40.0 %)
>3 years	12 (60.0 %)	10 (50.0 %)
Meal Arrangements		
Yes	17 (85.0 %)	13 (65.0 %)
No	3 (15.0 %)	7 (35.0 %)
Physical Activity		
Yes	15 (75.0 %)	8 (40.0 %)
No	5 (25.0 %)	12 (60.0 %)
Herbal Alternative		
Yes	10 (50.0 %)	8 (40.0 %)
No	10 (50.0 %)	12 (60.0 %)
Drug Ingestion Monitor		
Husband and wife	6 (30.0 %)	9 (45.0 %)
Child	10 (50.0%)	7 (35.0 %)
You	2 (10.0 %)	1 (5.0 %)
Other	2 (10.0 %)	3 (15.0 %)
Total	20 (100.0 %)	20 (100.0 %)

Table 5 shows that most control (70 %) and intervention (65 %) group respondents had sufficient carbohydrate intake before the intervention. Most respondents (90 %) had insufficient fiber intake before the intervention in both the control and intervention groups. Respondents in the intervention (70 %) and control (85 %) groups mostly had adequate carbohydrate intake after the intervention. Respondents in the control and intervention groups mostly had insufficient fiber intake after the intervention.

Table 5. Food Intake Characteristics of the Sample

Characteristics	Intervention	Control
Carbohydrate Intake Before Intervention		
More (>290.7 g)	7 (35.0 %)	6 (30.0 %)
Enough (≤290.7 g)	13 (65.0 %)	14 (70.0 %)
Fiber Intake Before Intervention		
Enough (≥30.0 g)	2 (10.0 %)	2 (10.0 %)
Not enough (<30.0 g)	18 (90.0 %)	18 (90.0 %)
Carbohydrate Intake After Intervention		
More (>290.7 g)	6 (30.0 %)	8 (40.0 %)
Enough (≤290.7 g)	14 (70.0 %)	12 (60.0 %)
Fiber Intake After Intervention		
Enough (≥30.0 g)	5 (25.0 %)	3 (15.0 %)
Not enough (<30.0 g)	15 (75.0 %)	17 (85.0 %)
Total	20 (100.0 %)	20 (100.0 %)

Blood sugar levels in the intervention and control groups

Table 6 shows that the mean value of blood sugar levels in the intervention group significantly decreased after consuming banana (*Musa sapientum L.*) peel biscuits together with the antidiabetic drug metformin, with a reduction of 18.9 mg/dL (-10.4 %) with a p-value of 0.002 < α 0.05. The mean value of blood sugar levels in the control group also decreased by 3.6 mg/dL (-1.8 %), with a p-value of 0.466 > α 0.05, which means there is no significant difference in blood sugar levels before and after taking only antidiabetic drugs such as metformin.

Table 6. Comparison of Blood Sugar Levels in Intervention and Control Groups both receiving metformin

Group	Variable	Mean (mg/dL)	SD	ΔMean (mg/dL)	Reduction (%)	p-value
Intervention (n=20)	Before	181.8	55.8	18.9	10.4	0.002
	After	162.9	43.6			
Control (n=20)	Before	198.4	58.9	3.6	1.8	0.466
	After	194.8	55.2			

Source: Wilcoxon test

DISCUSSION

Medicinal plants are frequently used in traditional medicine to treat different diseases in different areas of the world. Banana is an important sub-tropical fruit in international trade. It undergoes significant textural and color transformations during the ripening process, which in turn influences the eating quality of the fruit. In the present study, we assessed the organoleptic characteristics of banana peels used as a hypoglycemic adjuvant in diabetic mellitus patients consuming metformin as an antidiabetic treatment.

Color in food greatly affects the attractiveness and taste of food. Based on this study, when viewed from the criteria for like based on the percentage of color criteria, the banana (*Musa sapientum L.*) peel biscuit sample has like criteria with a score of 71 (94.67 %). The color of *Musa sapientum L.* peel biscuits is influenced by the brownish banana (*Musa sapientum L.*) peel flour. Color plays a critical role in food acceptability testing, as color can affect consumer acceptance of the food product. In addition, color can also indicate the quality of food made, and the assessment of color can also affect the taste of food (19).

The smell of food is caused by the ingredients used in making biscuits. Based on this study, the banana (*Musa sapientum L.*) peel biscuit sample has like criteria with a score of 70 (93 %). This is because the smell is quite difficult to measure, so it usually causes different assessments or opinions in achieving the quality of the scent. This difference in opinion can be caused by each person who has a difference in smell; although everyone can distinguish the smell, everyone also has different preferences (20).

Generally, in food assessment, the flavor of biscuits is usually the most important factor. Based on this study, the banana (*Musa sapientum L.*) peel biscuit sample has like criteria with a score of 59 (78,67 %). Banana (*Musa sapientum L.*) peel flour and wheat flour give the biscuits a more dominant flavor of banana peel (*Musa sapientum L.*) peel. The more banana (*Musa sapientum L.*) peel flour is used, the more distinctive the biscuit's taste will be. According to panelists, using quite a lot of banana (*Musa sapientum L.*) peel flour in the biscuits can cause a slightly bitter taste. Therefore, adding skim milk neutralized the bitter taste of the biscuits.

Food texture is defined as food properties sensed by touch in the mouth and with the hands. We use many words to describe food texture—foods can be soft or hard, mushy or crunchy, or smooth or lumpy. Texture is important to the enjoyment and acceptability of foods. Texture in food can be felt when bitten, chewed, swallowed, or held. It can also be seen from the shape of the biscuit. Based on this study, the *Musa sapientum L.* peel biscuit sample has 71 (81.3 %) similar criteria. The texture of the biscuits was influenced by the concentration of banana (*Musa sapientum L.*) peel flour.

Phytochemical Analysis

Banana peels (*Musa sapientum*) genus Musa are grown worldwide and have medicinal applications. The present study detected phytochemical characteristics of banana peels, showing that banana (*Musa sapientum L.*)

peel biscuits contain flavonoids, alkaloids, and tannins, which are 10.9 mg, 9.3 mg, and 14.8 mg per one piece of banana peel biscuits, or 20 grams of banana (*Musa sapientum L.*) peel biscuits. This is in line with Hikal et al., who demonstrated that banana (*Musa sapientum L.*) peel contains flavonoids of 19.6 grams and tannins of 5.8 grams per 100 grams of banana peel (21). Romelle et al. found that banana (*Musa sapientum L.*) peel contains 6.9 grams of alkaloids per 100 grams of banana peel. Our data concluded that the alkaloid content contained in banana (*Musa sapientum L.*) peel is within the safe threshold value so that banana peel can be used as an ingredient in the formulation of food products that are beneficial to health because the benefits of these compounds have been proven for health (22).

Intervention

Banana peel is a rich source of many bioactive compounds like carotenoids, biogenic amines, polyphenols, phytosterols, and antioxidants. It also contains minerals like iron, calcium, sodium, phosphorus, magnesium, and good levels of dietary fiber. The use of antioxidants present in banana peels can help reduce the risk of diseases like cancer. Banana peel carries anti-inflammatory properties that can be used daily as a first-aid at home to control, reduce, and cure inflammation and infections. Evidence shows banana peels may lower blood sugar levels in diabetic experimental models (6). The present study showed a significant reduction in blood sugar levels in the intervention group after giving banana (*Musa sapientum L.*) peel biscuits and taking antidiabetic drugs such as metformin (18.9 mg/dL; -10.4 %), with no significative reduction of blood sugar levels of the control group receiving only antidiabetic drugs (3.6 mg/dL; -1.8 %). This is in agreement with the results reported in diabetic mice given banana (*Musa sapientum L.*) peel extract, where it was demonstrated that 500 mg/kg banana peel extract can reduce glucose levels in the body by 25.5 % (6). This can occur because banana (*Musa sapientum L.*) peel contains alkaloids and flavonoids that can be antihyperglycemic and flavonoids and tannins that can be antioxidants (9).

Previous studies highlighted that among the various banana types, banana (*Musa sapientum L.*) peel stood out with a calculated antioxidant activity value of 97.8 %, placing it in the first place compared to the antioxidant activity of kepok banana peel, Uli banana peel, and horn banana. In addition, this study showed antioxidant activity tests on banana (*Musa sapientum L.*) peel using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method, an approach for measuring antioxidant properties. The methanol extract test with maceration method had an IC50 value of 46.8, so it was included in the category of very strong antioxidant activity, while in the antioxidant activity test on cavendish banana, the ethanol extract test of the peel with maceration method had an IC50 value of 121.3 so that it was included in the category of moderate antioxidant activity (9). The antioxidant activity in banana peel is 94.2 %, while in banana fruit is 70 % (10).

The significant reduction in blood sugar levels due to the administration of banana (*Musa sapientum L.*) peel biscuits is supported by the addition of stevia sweetener to replace cane sugar as a sweetener in banana (*Musa sapientum L.*) peel biscuits. The benefit of stevia leaf extract is its remarkable ability to reduce blood glucose levels, known by its hypoglycaemic effect (23).

Consumption of banana (*Musa sapientum L.*) peels coupled with antidiabetic drugs provides a better reduction in blood sugar levels than taking antidiabetic drugs alone. Banana (*Musa sapientum L.*) peel has a high fiber content that can suppress blood sugar levels. It is also rich in antioxidants. These properties make it very suitable for people with diabetes who have to monitor their fiber intake. This is in accordance with research, which states that high-fiber foods have low glycemic index levels, whereas foods with a low glycemic index, if consumed in the long term, can improve blood sugar control (24).

Another study conducted using kepok banana peel extract found that before being given kepok banana peel extract, the difference in mice's blood sugar levels before and after being given metformin 10 mg/kg was 92.1. In contrast, the difference in blood sugar levels of mice before and after being given kepok banana peel extract at doses of 400, 200 and 100 mg/kg was 134.7, 101.5, and 104.2 mg/dL. This shows that the effect of

kepok banana peel extract is stronger in reducing blood sugar levels compared to metformin (25). It can be concluded that the blood sugar levels in the intervention group receiving banana (*Musa sapientum L.*) peel biscuits were lower compared with the control group, suggesting that in addition to metformin therapy, adding banana (*Musa sapientum L.*) peel biscuits helps to reduce sugar blood levels in patients with diabetes mellitus. In this respect, Marella (2017) suggests that the flavonoid content in banana (*Musa sapientum L.*) peel can help increase insulin secretion through pancreatic beta-cell regeneration, increasing insulin sensitivity to glucose (26). In addition to flavonoid content, the presence of alkaloids and tannins in banana peel can also reduce blood sugar levels because it can inhibit glucose absorption and spur glucose metabolism (27,28). In addition, Inayati et al. (2020) determined the effect of hydroethanolic extract from Ambon banana peel (*Musa paradisiaca L*) on the reduction of blood glucose levels in streptozotocin-induced type 2 diabetes mellitus rats, with negative control, positive control, hydroethanol extract of Ambon banana peel dose 400 mg / KgBB, hydroethanol extract of Ambon banana peel dose 800 mg / KgBB treatment for 21 days (po). They showed that the average value of the difference in blood sugar levels after administering 400 and 800 mg/kg of Ambon banana peel extract was 131 and 129.6 mg/dL, the positive control group by administering 500 mg/kg of metformin was 108.5 and the negative control group that received standard feed and drinks experienced an increase in blood sugar levels of 68.6 mg/dL (p-value of 0.032), meaning the hydroethanolic extract of Ambon banana peel (*Musa paradisiaca L.*) can significantly reduce blood glucose levels in type 2 diabetes mellitus rats induced by streptozotocin, and that hydroethanolic extract of Ambon banana peel (*Musa paradisiaca L.*) at a dose of 400 mg/kg BW is the optimal dose to reduce blood glucose levels in hyperglycemic rats (29). Furthermore, *Musa sapientum* showed an antihyperglycemic effect in hyperglycemic rabbits (30). The chloroform extract of flowers of *M. sapientum* showed blood glucose and glycosylated hemoglobin reduction and total hemoglobin increase after oral administration in rats (31). It also controls lipid peroxidation in diabetes (32).

CONCLUSIONS

This study shows a significant reduction in blood sugar levels in patients with diabetes mellitus after receiving banana (*Musa sapientum L.*) peel biscuits and metformin antidiabetic drugs (p=0.002). At the same time, there was no difference in blood sugar levels in patients with diabetes mellitus taking only metformin as an antidiabetic drug (p=0.466). The use of banana (*Musa sapientum L.*) peel biscuits as a complementary therapy twice a day can effectively manage and reduce blood sugar levels in patients with diabetes mellitus accompanied by lifestyle and diet modifications and compliance with taking medication. This study concluded that banana (*Musa sapientum L.*) peel biscuits affect blood sugar levels in patients with diabetes mellitus in the Marusu and Mandai Health Centers Working Areas of Maros Regency.

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