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Antihyperglicemic effect of *Musa paradisiaca* extract in vivo

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A B S T R A C T

Background: *Musa paradisiaca* has been widely studied for its antihyperglycemic effects, showing potential as an alternative natural remedy for diabetes. However, variability in genetic factors, environmental conditions, and geographical origins may influence its bioactive compound composition and efficacy. Thus, further validation through controlled studies is required to ensure consistent therapeutic effects.

Purpose: : This study aimed to evaluate the antihyperglycemic effect of *Musa paradisiaca* stem extract in vivo, providing additional validation for its therapeutic potential and determining the optimal concentration for clinical relevance.

Method: An experimental posttest-only control group design was used. Thirty-five male Balb/c strain mice were induced into hyperglycemia using alloxan. They were then randomly divided into treatment groups receiving different concentrations of *Musa paradisiaca* stem extract (5%, 15%, 25%, 35%, and 45%), a positive control group (metformin), and a negative control group. Blood glucose levels were measured and analyzed statistically using One-Way ANOVA.

Result: Administration of the stem extract at 15% concentration showed the most significant antihyperglycemic effect, with an average blood glucose level reduction to 63.8 mg/dL, comparable to the positive control group (metformin). Conversely, the highest concentration tested (45%) exhibited minimal effectiveness, with an average glucose level of 151.8 mg/dL, indicating reduced antihyperglycemic activity.

Conclusion: The optimal antihyperglycemic effect of *Musa paradisiaca* stem extract was achieved at a concentration of 15%, demonstrating therapeutic efficacy comparable to metformin. This extract shows promise as a natural alternative agent in diabetes treatment. Further studies, including clinical trials, are recommended to confirm these findings.

INTRODUCTION

Hyperglycemia remains a significant public health concern worldwide, affecting millions of people annually and substantially increasing the risk of diabetes-related complications.[1] Globally, the prevalence of hyperglycemia ranges widely, but it notably affects around 10 million people per year in Indonesia alone, with substantial variations between urban areas (9.8%) and rural areas (2.8%). Overweight and hypertension have been identified as primary risk factors associated with hyperglycemia. Chronically elevated blood glucose levels (above 140 mg/dL) impair insulin function, leading to energy metabolism disorders and, ultimately, diabetes mellitus, which can affect various vital organs including the pancreas and kidneys.[1,4,5]

Oxidative stress induced by prolonged hyperglycemia can damage pancreatic β-cells, further impairing insulin secretion and exacerbating hyperglycemic conditions. Pharmacological treatments are commonly used; however, they often come with undesirable side effects, highlighting the necessity for safer, more sustainable, and cost-effective natural alternatives.[1] Recent studies suggest certain bioactive compounds like flavonoids, tannins, and saponins found in plants can exhibit antihyperglycemic activities through antioxidant mechanisms, enhancement of insulin secretion, and inhibition of glucose absorption. [6,7]

Musa paradisiaca (banana plant), particularly its stems, has attracted attention as a promising natural antihyperglycemic remedy.[8] Rich in bioactive compounds such as potassium, vitamin B6, tannins, and saponins, this plant is believed to possess properties beneficial in regulating glucose metabolism and supporting insulin production.[9-11] Previous research using various parts of *Musa paradisiaca* (roots, stems, leaves, and fruit) has confirmed its therapeutic potential in reducing blood glucose levels.[12-17] However,

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due to genetic variability, differences in environmental conditions, and geographical locations, the chemical composition and thus therapeutic efficacy of plant extracts can significantly vary. [18,19]

Despite numerous studies exploring the antihyperglycemic potential of *Musa paradisiaca*, additional research remains crucial, particularly to validate previous findings and assess the consistency of its therapeutic effects across different regions and cultivars. Therefore, this study aims specifically to evaluate the antihyperglycemic effect of *Musa paradisiaca* stem extract from local cultivars commonly found in Kalimantan. By providing robust experimental evidence, this research will contribute significantly to validating the efficacy and standardizing the utilization of *Musa paradisiaca* stem extract as a potential natural remedy for hyperglycemia.

METHOD

Study Design

The research method used a experimental study with posttest group design.[20]

Study Site

The research was conducted at the Microbiology Laboratory, Tadris Biology Department, State Islamic Institute of Palangka Raya, Central Kalimantan, Indonesia.

Materials

The materials used included 35 male Balb/c mice aged 3–4 weeks, weighing approximately 28 grams. *Musa paradisiaca* stems (cultivar manure) were extracted and prepared at concentrations of 5%, 15%, 25%, 35%, and 45%. Other chemicals included 70% alcohol, 96% ethanol, chloroform, Mayer's reagent, Dragendorff's reagent, Wagner's reagent, ammonia solution, NaOH, H_2SO_4, Mg-HCl powder, 1% hydrochloric acid, 1% iron (III) chloride, vaseline, aluminum foil, alloxan monohydrate, and metformin (as positive control). Equipment included an autoclave, beakers, Erlenmeyer flasks, glassware, magnetic stirrer, micropipette, incubator, digital scale, glucometer, gastric feeding tube, and microtubes.

Plant Extraction Process

Fresh *Musa paradisiaca* stems were selected, washed thoroughly with running water, cut into smaller pieces, air-dried at room temperature, and ground into powder (total of 1000 grams). The powder underwent extraction via maceration using 96% ethanol solvent for 24 hours.[20]

Bioactive Compound Test

Qualitative Tests for Secondary Metabolites

Extract (1 mg/mL) was tested for flavonoids, tannins, alkaloids, and saponins.[20] Flavonoid Test: 1 mL extract was mixed with 1 mL concentrated HCl and magnesium powder. Formation of an orange-red color indicated positive flavonoids. Alkaloid Test: 1 mL extract mixed with Dragendorff's or Mayer's reagent; formation of precipitate indicated presence of alkaloids. Saponin Test: 5 mL extract was shaken vigorously; stable foam indicated presence of saponins. Tannin Test: 1 mL extract mixed with 2 mL of 1% $FeCl_3$; dark green or blue color indicated positive tannins.

Quantitative Test of Bioactive Compounds

Quantitative tests included antioxidant activity (DPPH method), total flavonoids, tannins, and polyphenols.[20] Antioxidant Activity: DPPH radical scavenging activity measured at 517 nm using concentrations of extract (5%, 10%, 15%, 25%, 35%, 45%). Total Flavonoids: Measured at 415 nm using $AlCl_3$ reagent with quercetin standard. Total Tannins: Measured at 725 nm using Folin-Ciocalteu reagent with gallic acid standard.

Experimental Procedure

Mice were acclimated for one week and fasted 12 hours before induction. Hyperglycemia was induced by intraperitoneal injection of alloxan monohydrate (70 mg/kg body weight) dissolved in citrate buffer solution (0.1 M, pH 4.5). Blood glucose was measured seven days post-injection; hyperglycemia was defined as glucose levels ≥ 200 mg/dL. Mice were then randomly divided into seven groups (n=5 per group): Negative control (no treatment). Positive control (metformin). Five treatment groups administered *Musa paradisiaca* stem extract orally (via gavage) once daily for seven days with doses equivalent to extract concentrations: Group I: 200 mg/kg BW (5%); Group II: 400 mg/kg BW (15%); Group III: 600 mg/kg BW (25%); Group IV: 800 mg/kg BW (35%); Group V: 1000 mg/kg BW (45%). Blood glucose levels were measured at the end of the treatment period using a glucometer.[17-19]

Statistical Analysis

Blood glucose data were analyzed using One-Way ANOVA, followed by post hoc tests, to determine significant differences among groups. Statistical significance was set at p-value <0.05.

Ethical Consideration

This research received ethical approval from the Research Ethics Committee, Faculty of Medicine, University of Palangka Raya (No. 285/UN24.9/LL/2022), and was conducted according to ethical standards for animal research, including adherence to the principles of Replacement, Reduction, and Refinement (3Rs).

RESULTS

Secondary Metabolite Content

Qualitative phytochemical screening of *Musa paradisiaca* stem extract revealed the presence of alkaloids, tannins, terpenoids, and saponins. Flavonoid compounds were not detected qualitatively. These results indicate potential active compounds that could contribute to antihyperglycemic effects and support the use of this extract as a natural therapeutic agent.

Antioxidant Effect of Musa paradisiaca Stem Extracts

Antioxidant activity testing showed a positive correlation between extract concentration and DPPH radical inhibition (Figure 1). Inhibition increased significantly with higher concentrations; the lowest inhibition was 35% at a 5% concentration, while the highest was 80% at a 45% concentration. Moderate increases were observed between concentrations of 5%–25% (35% to 55%), indicating dose-dependent antioxidant capacity.

Quantitative Analysis of Bioactive Compounds

Quantitative testing showed that higher extract concentrations increased flavonoids, tannins, and polyphenols (Figure 2). Flavonoids rose from 3.5 mg (5%) to 19.3 mg (45%), tannins from 1.8 mg (5%) to 9.2 mg (45%), and polyphenols from 4.2 mg (5%) to 21.5 mg (45%). Polyphenols were the most dominant, correlating with the extract's antihyperglycemic potential.

Blood Sugar Level Reduction Activity Test in Mice

Blood glucose levels significantly decreased *with Musa paradisiaca* stem extract treatment. ANOVA showed a significant difference in glucose reduction between groups (F=12.816; p=0.000) (Table 1). The 15% concentration was most effective, reducing glucose to 63.8 mg/dL, similar to metformin. However, the highest concentration (45%) showed minimal reduction (151.8 mg/dL), indicating decreased effectiveness at higher doses (Table 2). A comparison of glucose levels before and after treatment confirms the optimal effect at 15% concentration (Figure 3).

Table 1. ANOVA results of antihyperglycemic effect of *Musa paradisiaca* stem extract

Source	Sum of squares	Mean Square	F	p-value
Between Groups	34253.600	6574.457	12.816	0.0001
Within Groups	17132.000	513.000		

Table 2. Mean blood glucose levels after treatment with *Musa paradisiaca* stem extract

Group	Concentration (%)	Mean Glucose Level (mg/dL)	Notation
P4	15	63.80	a
P5	25	84.40	a
P1 (Metformin)	Positive Control	84.80	a
P6	35	122.00	b
P3	5	138.40	b
P7	45	151.80	b
P2	Negative Control	153.40	b

Exp: Different letters (a,b) indicate statistically significant differences between groups at p<0.05.

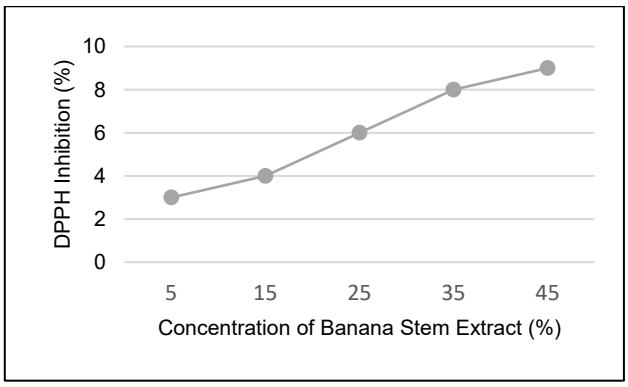

Figure 1. Antioxidant activity of *Musa paradisiaca* stem extracts

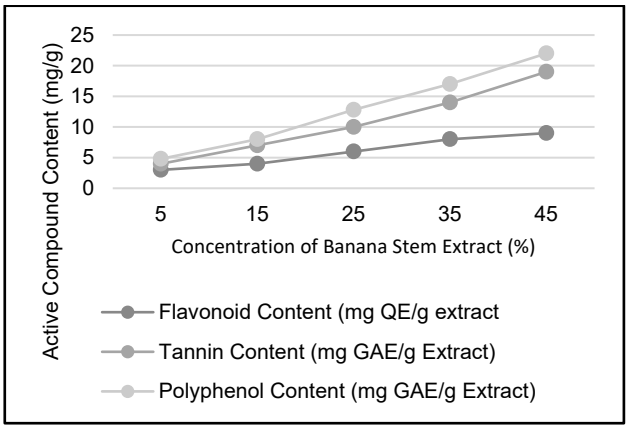

Figure 2. Bio-active compound content of *Musa paradisiaca* stem extracts

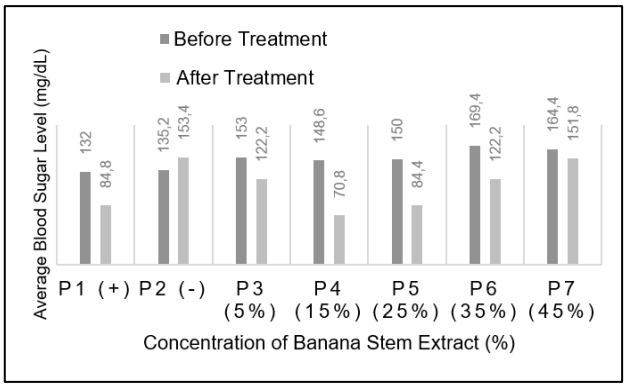

Figure 3. Comparison of Average Blood Sugar Level Reduction (mg/dl) in Hyperglycemic Mice After Treatment

DISCUSSION

The results of this study clearly demonstrate that *Musa paradisiaca* stem extract significantly reduces blood glucose levels in hyperglycemic mice. The antihyperglycemic effects observed in this study are attributed primarily to the presence of bioactive compounds, notably saponins and tannins. Saponins are known to promote hypoglycemic effects by stimulating pancreatic β-cell regeneration, enhancing insulin secretion, and improving insulin sensitivity. Meanwhile, tannins play a complementary role by reducing oxidative stress and slowing intestinal glucose absorption. These mechanisms

collectively contribute to improved glucose homeostasis. [21-26]

Quantitative analysis revealed a dominant polyphenolic content, which aligns with the observed antioxidant activity. Interestingly, despite the qualitative phytochemical tests indicating the absence of flavonoids, quantitative tests confirmed their presence in measurable amounts. This discrepancy suggests that the flavonoid concentration might have been below detectable limits in qualitative assays or indicates variability in sensitivity between qualitative and quantitative methods. Further investigation is recommended to clarify this finding.[27,28]

The statistical analysis showed that a 15% concentration of *Musa paradisiaca* stem extract exhibited optimal antihyperglycemic activity, comparable to the positive control group receiving metformin. This finding is consistent with previous studies reporting the antihyperglycemic potential of various parts of the *Musa paradisiaca* plant, including leaves, fruits, and roots.[27] Nevertheless, an unexpected finding emerged at the higher concentration (45%), where a significantly reduced antihyperglycemic effect was observed. This might be attributed to bioactive compound saturation or interactions leading to antagonistic effects at higher doses, although further studies are necessary to explore this possibility.[28,29]

At the molecular level, the hypoglycemic effect of saponins can be explained by the stimulation of pancreatic β-cell proliferation and increased insulin secretion through the mitogen-activated protein kinase (MAPK) and Akt pathways, as well as upregulation of pancreatic and duodenal homeobox 1 (PDX-1), a key regulator of β-cell differentiation.[30] Additionally, saponins might modulate the microenvironment of pancreatic cells by promoting secretion of growth factors such as insulin-like growth factor (IGF) and epidermal growth factor (EGF), facilitating cell proliferation and differentiation.[31]

Compared to previous studies, this research emphasizes the stem part of the *Musa paradisiaca* plant, which has been less explored as an antihyperglycemic agent. Variations in the antihyperglycemic effects observed across different plant parts, varieties, and extraction methods further underscore the importance of regional and botanical factors influencing bioactive compound profiles. Thus, this study provides additional evidence supporting the therapeutic use of *Musa paradisiaca* stem extract, particularly cultivars from Kalimantan, for hyperglycemia treatment.[32]

Despite promising results, this study has limitations, including the absence of histopathological analysis to directly visualize pancreatic regeneration and insulin-producing β-cell recovery. Future studies should address this gap and explore molecular-level changes and safety aspects in greater depth. Clinical studies are also necessary to translate these promising preclinical findings into human therapeutic applications.

CONCLUSIONS AND RECOMMENDATION

Musa paradisiaca stem extract effectively reduces blood glucose levels in hyperglycemic mice, with an optimal concentration of 15%, comparable to metformin. The antihyperglycemic effects are primarily due to the presence of saponins, which enhance insulin secretion, and tannins, which reduce oxidative stress and inhibit glucose absorption. Further research should explore detailed molecular mechanisms and conduct clinical trials to validate the extract's therapeutic potential as a natural antihyperglycemic agent for diabetes management.

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