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ORIGINAL ARTICLE

The effect of gelagah stem extract on blood glucose levels in male white rats induced with alloxan

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ABSTRACT

Diabetes mellitus is a metabolic disorder characterized by elevated blood glucose levels due to insulin deficiency, insulin resistance, or both. This study aimed to investigate the effects of gelagah stem extract (*Saccharum spontaneum* L.) on blood glucose levels in male Sprague-Dawley rats induced with alloxan. Experimental rats were divided into six groups: a normal control group, a negative control group (administered 100 mg/kg body weight alloxan), a positive control group (administered 5 mg/kg body weight glibenclamide), and three treatment groups administered gelagah stem extract at doses of 100, 200, and 400 mg/kg body weight. Results showed that all doses of gelagah stem extract significantly reduced blood glucose levels in alloxan-induced diabetic rats. Statistical analysis (Post hoc LSD) confirmed that the decrease in blood glucose levels was significantly different between the treatment groups and the negative control group ($p < 0.05$).

Keywords: diabetes mellitus, gelagah stem, alloxan-induced diabetes, medicinal plant extract

Introduction

As an archipelagic country, Indonesia boasts a rich biodiversity, particularly in terms of medicinal plants. However, the potential of these plants and their bioactive compounds as an alternative treatments has not been fully investigated. Thus, various complementary and alternative medicine practices have been adopted to manage chronic degenerative diseases such as diabetes.[1] WHO has advocated for the incorporation of traditional medicine, especially in the management of degenerative conditions like diabetes mellitus, as a strategy for improving public health, encompassing both preventive and curative aspects.[2] In Indonesia, diabetes mellitus remains a significant public health concern, mirroring global trends. The International Diabetes Federation estimated 463 million individuals with diabetes in 2019, a figure projected to rise to 578 million by 2030 and 700 million by 2045. This increasing prevalence is likely driven by lifestyle changes and rising socioeconomic standards.[3]

Diabetes mellitus is a metabolic disease affecting the pancreas, leading to hyperglycemia, which is a condition characterized by abnormally high levels of glucose in the blood.[4] Metabolic disorders are often caused by insulin deficiency. Insulin plays a crucial role in converting glucose into energy.[2] As a hormone

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produced by the beta cells of the pancreas, insulin regulates blood glucose levels by controlling glucose uptake and storage. Insulin insufficiency or resistance results from the dysfunction of the beta cells, which are responsible for insulin production.[5]

Diabetes mellitus is diagnosed when individuals present with characteristic symptoms including polyuria, polydipsia, polyphagia, weight loss, fatigue, paresthesia, visual disturbances, or impaired wound healing.[6] The diagnosis is confirmed through blood tests revealing a fasting plasma glucose level of 126 mg/dL or higher, a two-hour post-load plasma glucose level of 200 mg/dL or higher, a random plasma glucose level of 200 mg/dL or higher, or an HbA1c level of 6.5% or higher. Diabetes can be classified based on its etiology, which includes: type 1 caused by the destruction of pancreatic beta cells resulting in insulin deficiency, type 2 caused by insulin resistance accompanied by impaired insulin secretion, gestational diabetes mellitus occurring during pregnancy, and other types of diabetes resulting from medications, chemicals, immunological infections, and other genetic disorders.[7]

The high prevalence of diabetes in Indonesia has stimulated research into the development of antidiabetic drugs derived from plants as traditional medicine. Traditional medicine, often passed down through generations, comprises formulations from natural sources such as plants, animals, minerals, and galenicals, or combinations thereof.[8] One plant with potential antidiabetic properties is *Saccharum spontaneum L.* or gelagah. Various parts of this plant, including the roots, stem, and leaves, contain a rich array of bioactive compounds like lignin, carbohydrates, proteins, amino acids, starch, and polyphenols.[9] Phytochemical analysis of the ethanolic extract of the stem has revealed the presence of flavonoids, alkaloids, terpenoids, saponins, tannins, phenols, steroids, and glycosides.[10]

In Kumango Village, Rokan Hulu, Riau, Indonesia, local communities traditionally use the stem of gelagah as an antidiabetic remedy. A decoction prepared by boiling the stem in 500 ml of water is consumed daily. The ethanolic extract of the stem is known to contain bioactive compounds, particularly flavonoids, which are believed to contribute to its antidiabetic effects.[11] The antioxidant properties of flavonoids are thought to play a crucial role in protecting pancreatic beta cells from damage caused by free radicals.[12] Based on the foregoing, this study aims to investigate the hypoglycemic effects of the ethanolic extract of gelagah stem in male Wistar rats induced with alloxan. The objective is to provide scientific evidence supporting the traditional use of this plant in managing diabetes mellitus.

Method

This quantitative study employed the alloxan-induced hyperglycemia model using 30 male Wistar rats (*Rattus norvegicus*) divided into six groups of five. Experiments were conducted in the Faculty of Medicine Laboratory, Universitas Prima Indonesia. Primary data was collected by evaluating the effects of gelagah stem extract on blood glucose levels in alloxan-induced hyperglycemic rats.

Equipment: A blender, rotary evaporator, beaker glasses, stirring rods, mortar and pestle, dropping pipettes, test tubes, spot plates, filter paper, funnels, graduated cylinders, Erlenmeyer flasks, analytical balance, animal housing cages, syringes, oral sonde, test tubes, test tube racks, cotton, stopwatch, gloves, mask, glucometer, and Multicheck Nesco® test strips were utilized. Materials: Pandanus leaves, male white rats, alloxan, glibenclamide (0.1 mg/200 mgBW), analytical-grade ethanol, chloroform, sulfuric acid, 2N HCl, Mayer's reagent, Dragendorff's reagent, magnesium metal, concentrated HCl, methanol, 1% ferric chloride, 3% ferric chloride, distilled water, anhydrous acetic acid, and concentrated sulfuric acid were employed.

Prior to the experiment, all equipment and materials were sterilized. Fresh gelagah stems were collected and thoroughly cleaned by rinsing under running water to remove any adhering soil, roots, or leaves. The cleaned stems were then air-dried and subsequently cut into smaller segments. These segments were further comminuted using a blender before being transferred to a drying oven. The dried material was then ground into a fine powder. A maceration method was employed for the extraction of bioactive compounds from the gelagah stem powder. The powdered sample was placed in a maceration vessel, and 96% ethanol was added as the solvent. The mixture was sealed and allowed to macerate for 3 days with occasional stirring every 24 hours for 10 minutes. The resulting macerate was then filtered using filter paper to separate the extract from the marc. The filtrate was concentrated using a rotary evaporator at a temperature of 69-70°C until a viscous extract was obtained. The concentrated extract was subjected to phytochemical screening to identify the presence of various bioactive compounds including alkaloids, flavonoids, phenols, saponins, terpenoids, and steroids.

Thirty male rats were acclimatized for seven days. The animals were then randomly divided into six groups, each consisting of five rats: a healthy control group, a diabetic control group treated with alloxan and distilled water, a positive control group receiving alloxan and the antidiabetic drug glibenclamide, and three treatment groups administered alloxan and varying doses of gelagah stem extract. Three dose levels of gelagah stem extract (100 mg/kg, 200 mg/kg, and 400 mg/kg body weight) were administered orally to the experimental groups. A preliminary study was conducted to determine the optimal dose of alloxan to induce diabetes in rats. Alloxan solution was administered intraperitoneally, and the rats were monitored for the development of hyperglycemia. Blood glucose levels were monitored every 30 minutes for 3 hours after treatment initiation to assess the effects of the extract compared to the controls and standard drug.

Results and Discussion

To assess the antidiabetic potential of gelagah stem extract, an experimental study was conducted using male white rats. Initially, rats were fasted for approximately eight hours to ensure an empty gastrointestinal tract, optimizing drug absorption. Diabetes was induced by a single intraperitoneal injection of alloxan (100 mg/kg body weight) on day zero. Blood glucose levels were monitored on days 3, 7, and 14 post-induction. Hyperglycemia was confirmed by fasting blood glucose levels exceeding 126 mg/dl. Subsequently, the antidiabetic efficacy of gelagah stem extract was evaluated. Animals were randomly divided into six groups: Group 1 (normal control): no treatment; Group 2 (negative control): injected with alloxan and administered distilled water; Group 3 (positive control): injected with alloxan and treated with glibenclamide (5 mg converted to 0.016 ml for a 200-gram rat), a known antidiabetic drug with a mechanism of action similar to flavonoids or saponins; and Groups 4-6: injected with alloxan and treated with gelagah stem extract at doses of 100, 200, and 400 mg/kg body weight, respectively.

Treatment with gelagah stem extract or glibenclamide commenced on the day hyperglycemia was confirmed and continued for 14 days. Blood glucose levels were measured at 30, 60, 90, 120, 150, and 180 minutes post-treatment. Table 1 presents the blood glucose levels of rats measured at pre-test time points (H0, H3, H7, H14) and post-test time points (M30, M60, M90, M120, M150, M180). Each treatment group consisted of five rats. The table also displays the mean blood glucose levels for each treatment group.

Table 1. Measurements of blood glucose levels in male white rats

No.	0	3	7	14	M30	M60	M90	M120	M150	M180
K1	94.00	73.40	106.00	94.40	95.60	95.20	94.60	100.60	100.40	101.40
K2	81.60	97.80	157.60	265.60	318.20	318.80	327.20	353.60	345.00	353.20
K3	93.60	108.20	158.60	222.80	173.60	169.60	164.60	147.40	125.20	115.60
K4	94.80	142.60	156.40	212.80	194.60	190.00	187.00	183.80	115.60	99.40
K5	101.40	144.20	182.40	229.00	225.20	221.20	221.80	122.80	93.20	90.60
K6	98.20	161.40	175.20	222.20	218.20	212.40	120.00	105.00	96.60	91.40

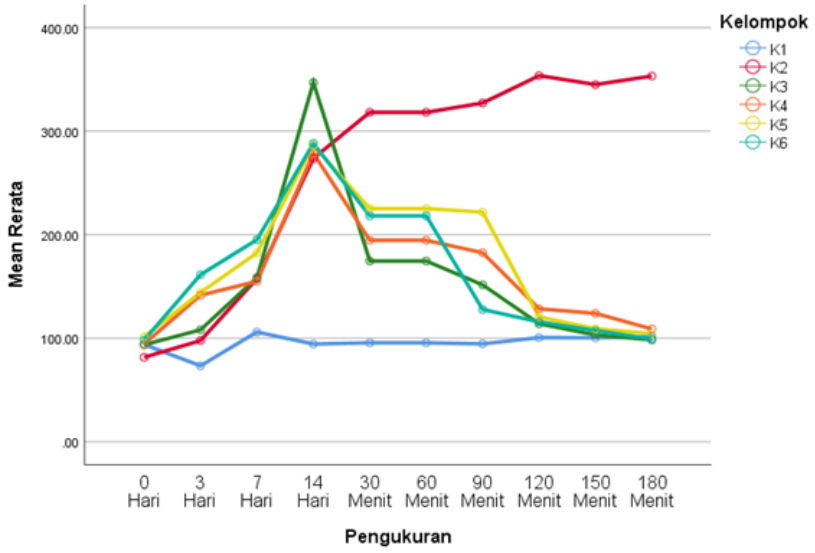

Figure 1. Average Blood Glucose Reduction in Male White Rats

The data indicates that the blood glucose levels of all male albino rats increased following induction. The mean blood glucose levels of the negative control, positive control, and treatment groups P1, P2, and P3 exhibited an increase from day 0 to day 14, exceeding 300 mg/dL. Subsequent post-test measurements revealed a decrease in blood glucose levels in both the positive control group and the groups treated with vetiver root extract. Conversely, the negative control group continued to show an increase in blood glucose levels, likely due to the absence of any treatment or therapy beyond the administration of distilled water as a comparison.

The decrease in blood glucose levels in rats induced with alloxan following the administration of gelagah stem extract may be attributed to the presence of various bioactive compounds including alkaloids, flavonoids, saponins, phenols, and triterpenoids. Alkaloids are believed to lower blood glucose levels by enhancing glucose transport, inhibiting glucose absorption, stimulating glycogen synthesis, and increasing glucose oxidation. The antioxidant properties of flavonoids contribute to their antidiabetic effects by protecting pancreatic beta cells from oxidative damage.[12] Saponins act by inhibiting glucose absorption in the intestines, leading to increased insulin secretion and glucose uptake.[13] Phenols prevent damage to pancreatic beta cells and enhance insulin secretion.[12] Triterpenoids can lower blood glucose levels by stimulating insulin release from the pancreas.[14] Based on these findings, it can be concluded that gelagah stem extract exhibits hypoglycemic activity in rats. However, its efficacy is lower compared to glibenclamide, as evident in the table and graph. The decrease in blood glucose levels was more rapid with glibenclamide treatment than with the plant extract.

Table 2. Results of analysis with LSD post hoc test

Time of observation	Intervention	KN	K(-)	K(+)	KP1	KP2	KP3
30 minutes	K N		.000	.000	.000	.000	.000
	K (-)	.000		.000	.000	.000	.000
	K (+)	.000	.000		.011	.000	.000
	K P1	.000	.000	.011		.000	.003
	K P2	.000	.000	.000	.000		.342
	K P3	.000	.000	.000	.003	.342	
60 minutes	K N		.000	.000	.000	.000	.000
	K (-)	.000		.000	.000	.000	.000
	K (+)	.000	.000		.155	.000	.000
	K P1	.000	.000	.155		.000	.001
	K P2	.000	.000	.000	.000		.292
	K P3	.000	.000	.000	.001	.292	
90 minutes	K N		.000	.000	.000	.000	.000
	K (-)	.000		.000	.000	.000	.000
	K (+)	.005	.000		.000	.000	.001
	K P1	.000	.000	.000		.000	.000
	K P2	.000	.000	.000	.000		.000
	K P3	.000	.000	.001	.000	.000	
120 minutes	K N		.000	.100	.002	.018	.064
	K (-)	.000		.000	.000	.000	.000
	K (+)	.100	.000		.079	.408	.820
	K P1	.002	.000	.079		.330	.121
	K P2	.018	.000	.408	.330		.546
	K P3	.064	.000	.820	.121	.546	
150 minutes	K N		.000	.805	.046	.439	.537
	K (-)	.000		.000	.000	.000	.000
	K (+)	.805	.000		.075	.597	.711
	K P1	.046	.000	.075		.198	.151
	K P2	.439	.000	.597	.198		.874
	K P3	.537	.000	.711	.151	.874	
180 minutes	K N		.000	.001	.412	.744	.811
	K (-)	.000		.000	.000	.000	.000
	K (+)	.001	.000		.000	.000	.002
	K P1	.412	.000	.000		.618	.292
	K P2	.744	.000	.000	.618		.573
	K P3	.811	.000	.002	.292	.573	

The results of the one-way ANOVA indicated a significant reduction ($p < 0.05$) in blood glucose levels across the different treatment groups at the measurement timepoint. Post-hoc LSD analysis revealed a significant difference in blood glucose levels between all treatment groups receiving gelagah stem extract

and the normal control group. Within the treatment groups, a significant reduction in blood glucose levels was observed between the positive control (K+) group and the P1, P2, and P3 groups at the 180-minute mark ($p<0.05$). However, this difference was not significant at the 120 and 150-minute marks ($p>0.05$).

Data analysis demonstrated that administration of gelagah stem extract at doses of 100 mg/kg, 200 mg/kg, and 400 mg/kg significantly reduced blood glucose levels in male white mice. The most significant reduction was observed at the 400 mg/kg dose, approaching the efficacy of glibenclamide. These findings suggest that the active compounds in gelagah stem extract possess the potential to lower blood glucose levels.

Conclusion

The study findings indicate that gelagah stem extract possesses hypoglycemic properties, as evidenced by a notable reduction in blood glucose levels in alloxan-induced diabetic rats. The 400 mg/kg body weight dosage exhibited the most pronounced hypoglycemic effect when compared to lower dosages.

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