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Evaluation of *Solanum lasiocarpum* Fruit Extract on Blood Glucose, Hematological Parameters, and Liver and Kidney Function in Alloxan-induced Diabetic Rats

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Abstract: Hyperglycemia is characterized by elevated blood glucose levels that can lead to diabetes mellitus. Diabetes mellitus is primarily caused by insulin resistance and impaired insulin secretion. Eggplant (*Solanum lasiocarpum*) is a herbal plant traditionally used as a remedy for the management of diabetes mellitus. In recent studies *S. lasiocarpum* showed significant potential for glucose uptake. This study aimed to evaluate the effect of *S. lasiocarpum* fruit extract on blood glucose levels, hematological parameters, SGPT, SGOT, creatinine, and ureum levels in alloxan-induced diabetic rats. The study employed a completely randomized design with six groups: G1 (normal control), G2 (diabetic control), G3 (metformin control), G4 (extract 200 mg/kg BW), G5 (extract 300 mg/kg BW), and G6 (extract 400 mg/kg BW). SGPT, SGOT, ureum, and creatinine levels were measured using a spectrophotometern, blood sugar levels were measured using a glucometer and hematological levels were measured using hematology analyzer. Data were analyzed using one-way ANOVA followed by Duncan's multiple range test and revealed significant differences ($p < 0.05$) between the control and treatment groups in blood glucose levels, hematological parameters, SGPT, SGOT, creatinine, and urea levels with an optimal dose of 400 mg/kg body weight.

Keywords: diabetes mellitus; *Solanum lasiocarpus*; SGPT; SGOT; ureum; creatinine.

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Introduction

Diabetes mellitus is one of numerous degenerative conditions that have become prevalent in today's society. According to Bilous and Donelly (2015), diabetes mellitus is a metabolic condition characterized by increased blood sugar levels due to insulin resistance or decreased insulin synthesis. Data from the International Diabetes Federation (IDF) in 2019 showed that 463 million people worldwide had diabetes, and the figure is expected to rise by 51% over the period 2030–2045 (IDF, 2019). In 2012, diabetes mellitus led to 1.5 million deaths, 43% of which happened in individuals under 70 years old (WHO, 2018). Indonesia is one of the countries that has a high prevalence of diabetes. According to the Indonesian Ministry of Health's 2018 Basic Health Research, the majority of diabetes cases occur in women aged 55–64 and men aged 65–74. The number of diabetics in Indonesia is more women (1.8%) than men (1.2%) (Kementerian Kesehatan Republik Indonesia, 2018).

Diabetes arises from a disruption in the function of the hormone insulin, which is produced by cells on the Langerhans islet of the pancreas. As an endocrine gland, the pancreas will produce the hormones insulin and glucagon. Insulin is one of the important hormones in the body that functions as a controller of glucose levels in the blood. This disruption in insulin will cause hyperglycemia or increased blood sugar levels, which is

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then referred to as diabetes mellitus (Fox, C., & Kilvert, 2010). Hyperglycemia can cause dysfunction and organ failure that will lead to ongoing complications in diabetes (Thieu et al., 2019).

In general, diabetes mellitus is treated using therapies such as insulin injections to help maintain blood glucose balance (Kelly et al., 2011) and oral antidiabetic drugs (Barbosa et al., 2013). The use of oral antidiabetic drugs can cause ongoing side effects (Amjad et al., 2019). As a result of the unwanted effects of oral antidiabetic medications, researchers began to look for other treatment alternatives for diabetics. Traditional medicine that uses herbal plants was then found as an alternative treatment for diseases, including diabetes (Rehman et al., 2018). The WHO states that in some continents, such as Asia and Africa, around 80% of the population uses medicinal plants as a primary health care alternative (Afiqoh et al., 2017; Park & Kim, 2014). In addition, the Ministry of Health encourages the public to use traditional medicines such as herbal medicine, phytopharmaceuticals, and standardized herbal medicines to support disease prevention and overall-health (Kemenkes, 2020).

Many people believe that eggplant (*S. Lasiocarpum*) can be used as a traditional medicine that can cure pinworm infections (Hwong et al., 2019). In addition, people often use eggplant (*S. lasiocarpum*) as an alternative treatment for diabetes (Suwardi et al., 2021). Solanum lasiocarpum has been traditionally consumed and utilized as a medicinal plant in several regions of China, particularly in the Guangxi and Hunan provinces, for more than 300 years. Recent studies have indicated that mogrosides and polysaccharides isolated from the plant possess the ability to improve insulin resistance, thereby supporting blood glucose regulation and exhibiting antidiabetic activity. Although additional clinical investigations are still required to confirm its efficacy and safety in larger populations, existing findings indicate that *Solanum lasiocarpum* has considerable potential for diabetes management.

In Malaysia, the plant is widely known as "terung asam" and is mainly valued for its medicinal applications. Traditional practices involve using root decoctions to relieve severe body pain and postprandial discomfort. The roots are also incorporated into medicinal baths for fever treatment and applied as poultices to manage itching, cuts, wounds, and bruises. Similarly, in India, the plant has long been employed in traditional remedies, including the treatment of syphilis and the reduction of swelling through the topical application of leaf poultices (Zhao, et al., 2025).

Traditionally, *Solanum lasiocarpum* has also been recognized for its antidiabetic properties. Fruit extracts are commonly administered at doses between 50 and 200 mg/kg for various therapeutic purposes. Supporting this, Nguyen et al. (2019) demonstrated notable antidiabetic activity at a dosage of 100 mg/kg in streptozotocin-induced diabetic rats. Furthermore, WHO monographs (2005) have documented the plant's medicinal applications and effective dosage ranges, reinforcing its therapeutic value. Collectively, these findings provide both traditional and scientific evidence regarding the efficacy of *Solanum lasiocarpum* in conventional medicine. Therefore, the present study was conducted to evaluate the antidiabetic potential of the plant using both in vitro and in silico approaches (Zhao, et al., 2025).

Although people have traditionally used it as a medicine, preclinical research is required to assess how eggplant extract influences blood glucose and bodily organs, since prolonged use of herbal remedies can have harmful effects if not carefully controlled. Preclinical research on experimental animals is required before testing on humans; thus, in this study, white rats with physiological parallels to humans are used. So that the research findings can be applied to the next preclinical stage.

Materials and Methods

Preparation of Eggplant Fruit Extract (*Solanum lasiocarpum*)

Eggplant (*Solanum lasiocarpum*) was cut with a thickness of ± 5 mm and then dried. The drying process was carried out in the oven. The dried eggplant fruit was ground into simplicia powder with temperature 40-50°C and time for 5-12 hours. The resulting powder was then macerated in 96% ethanol for 3 × 24 hours, with stirring every hour during the first 6 hours of soaking. This maceration process was carried out with the calculation that every 25 grams of simplicia will be soaked with 250 ml of 96% ethanol. The soaking solution is then filtered using filter paper, and the dregs of the medicinal plants are macerated again using the same solvent. This process is repeated three times over three consecutive days until the filtrate is clear, and then filtered. The resulting filtrate is then concentrated using a rotary evaporator. Furthermore, the filtrate is put into an HPDE plastic bottle, then tightly closed and put into a container to be taken to Natural Materials Chemistry Laboratory of Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara to be extracted with a rotary evaporator. Phytochemical screening of the extract was conducted at the Universitas Sumatera Utara Pharmaceutical Biology Laboratory.

Experimental design.

This study is experimental laboratory research using a complete randomized design. This study used 30 male rats (*Rattus norvegicus*) aged 9-11 weeks with a weight of 180-200 grams. Rats were given the freedom to eat and drink according to standards in animal experiments conducted on experimental animals.

The experimental animals were divided into six groups, including a normal control group (G1) with no treatment, a diabetic control group (G2) treated with alloxan 150 mg/kg BW, a metformin control group (G3) given alloxan 150 mg/kg BW combined with metformin 45 mg/kg BW, as well as three treatment groups: G4 (alloxan 150 mg/kg BW + eggplant extract 200 mg/kg BW), G5 (alloxan 150 mg/kg BW + eggplant extract 300 mg/kg BW), and G6 (alloxan 150 mg/kg BW + eggplant extract 400 mg/kg BW).

All rats except the normal group (G1) were injected with a single dose of alloxan 150 mg/kgBW intraperitoneally. Blood sugar levels were then checked periodically on days 1, 4, and 14. Mice injected with alloxan (G4, G5, G6) were then given orally extract of Dayak eggplant (*Solanum lasiocarpum*) at doses of 200 mg/kgBW; 300 mg/kgBW; 400 mg/kgBW once a day for 14 days, while the metformin control group (K3) was given the standard metformin drug 45 mg/kgBW. Administration was carried out orally through the oral cavity, passing through the esophagus until it ended at the base of the stomach using a gavage needle and a 3 mL syringe. Treatment in Group 2, 3, 4, 5 and 6 were repeated five times.

Blood Glucose Measurement

The rats were fasted for 5 hours, then their blood was drawn through the tail vein and placed on a glucometer strip. The strip was inserted into the glucometer, and the blood glucose reading automatically appeared on the device. Post-induction BGL examination was carried out on the 5th day after alloxan induction. Blood Glucose Levels (BGL) during the study period were measured 3 times, namely initial BGL before treatment, BGL after alloxan-induced, and BGL after extract treatment

Complete blood profile measurement

The rats' blood was drawn from the orbital sinuses of the eye with a 2 cc hematocrit pipette and stored in an EDTA tube before being sent to measure the number of erythrocytes, leukocytes, platelets, and hemoglobin in using a Hematology analyzer at North Sumatra Province's Regional Health Laboratory.

Measurement of SGPT and SGOT

Measurement of SGPT (Serum Glutamic Pyruvic Transaminase) levels was carried out by the kinetic method using a dialab kit. The working procedure starts with the preparation of equipment in the form of test tubes that have been sterilized, and materials consisting of blood serum as much as 100 µ/l and 1000 µ/l of GPT working reagent are added and then homogenized. The measurement was then taken using a spectrophotometer at a wavelength of 340 nm. The reading results are entered into the following formula:

$$GPT\ [U/L] = \Delta A \times Factor$$

Meanwhile, SGOT (serum glutamate oxaloacetate transaminase) levels were measured using the same procedures as previously mention in SGPT measurement, but the GOT was used as working reagent. The results are then substituted into the formula:

$$GOT\ [U/L] = \Delta A \times Factor$$

Measurements of creatinine and ureum

Creatinine and ureum levels were measured after centrifugation of blood and serum samples for 15 minutes each. Next, add 1000 µL of phosphate buffer and incubate for 5 minutes at 25°C. Finally, add 1000 µL of sodium hypochlorite. It was left for 10 minutes at 25°C before being measured with UV-VIS spectrophotometry at a wavelength of 578 nm. Results from absorbent measurements were recorded.

Data Analysis

The data for glucose levels, full blood profiles, SGPT, SGOT, creatinine, and urea were analyzed using SPSS with the ANOVA one-way test and Duncan's Multiple Range Test was conducted at a 5% significance level. Additionally, observations of the pancreas' histological structure were carried out.

Result and Discussion

Blood Glucose levels

The BGL measurements for each rat are presented in Table 1.

Table 1 Blood Glucose Levels

Group	Baseline BGL (mg/dL)	BGL Post Induced Alloxane (mg/dL)	BGL Post treatment of Extract (mg/dL)
G1	98,80 ± 14,60^{ns}	99,20 ± 14,94^{a}	101,60 ± 14,59^{a}
G2	99,20 ± 13,61 ^{ns}	412,80 ± 77,64^{b}	407,80 ± 39,10^{d}
G3	93,20 ± 9,65 ^{ns}	407,00 ± 89,41^{b}	104,80 ± 12,07^{ab}
G4	97,00 ± 12,02 ^{ns}	406,60 ± 65,93^{b}	150,40 ± 21,10^{c}
G5	96,40 ± 7,40 ^{ns}	408,60 ± 81,08^{b}	131,60 ± 13,22^{bc}
G6	95,60 ± 5,55 ^{ns}	411,60 ± 66,58^{b}	116,40 ± 13,69^{ab}
p-value	0,958	0,000	0,000

Description: The value shows the average ± standard deviation (n=5). G1: normal control, G2: diabetes control, G3: metformin control, G4: extract dose 200 mg/kg BW, G5: extract dose 300 mg/kg BW, and G6: extract dose 400 mg/kg BW. ^{abc} The number followed by different letters in one column shows a real difference ($p<0.05$). ^{NS} shows non-significant.

According to Table 1, There was a significant increase in BGL by 3-4 times compared to the initial BGL in groups 2, 3, 4, 5, and 6. These results confirm that DM induction was successfully achieved with a single intraperitoneal injection of 150 mg/kg BW alloxan. According to Elekofehinti et al. (2013), the administration of alloxan led to a significant increase in blood glucose levels maintained for 3 weeks.

Alloxan is an unstable hydrophilic compound and has a form identical to glucose. Due to its glucose-like structure, alloxan can be transported into the cytosol by GLUT2 in the plasma membrane of pancreatic β-cells. In the process, alloxan induces a multiphase blood glucose response in experimental animals, which will be followed by an inversely proportional change in plasma insulin concentration at the same time as the final result in a sequential change in the cell structure of the pancreas that leads to cell death. The last phase of the alloxan induction process is the state of permanent diabetic hyperglycemia after the degranulation of pancreatic β cells, which is characteristically evident within 24–48 hours post-administration of alloxan in experimental animal studies. (Rohilla & Ali, 2012).

The BGL post-extract treatment examination of the extract was carried out at the end of the research period. The ANOVA one-way test on BGL after extract treatment obtained a value of $p<0.05$, then the post-doc Duncan's test revealed a significant difference in post-treatment BGL between group 1 and groups 2, 4, and 5. Meanwhile, BGL after treatment between groups 1 and 6 found no significant difference. This means that statistically, the BGL in the group given the dose of *S. lasiocarpum* fruit extract 400 mg/kg BB per day is the same as the BGL of the normal control group. Groups 4 and 5, although not significantly different from group 1, showed that BGL decreased to within the normal range in rats, implying that *S. lasiocarpum* fruit extract can reduce blood glucose levels in diabetic rats for 14 days, with 400 mg/kg BW identified as the most effective dose.

The decrease in BGL related to the antioxidants contained in *S. lasiocarpum* fruit extract, such as flavonoids, has a positive effect on the management and prevention of hyperglycemia. Flavonoids reduce BGL through multiple mechanisms, including inhibition of glucose absorption, stimulation of glucose uptake in peripheral tissues, regulation of carbohydrate-metabolizing enzymes, and insulin-like activity. (Cazarolli et al., 2008). Flavonoids from *S. lasiocarpum* fruit extract also have antidiabetic effects. The hypoglycemic and regenerative effects of Langerhans islets in diabetic rats administered with *S. nigrum* extract are referred to as the flavonoid content in the extract (Umamageswari et al., 2017)..

In addition to flavonoids, the saponins in eggplant extract have also been reported to help lower BGL (Elekofehinti et al., 2013). riterpenoid saponins in *S. lasiocarpum* fruit extract may exert hypoglycemic and hypolipidemic effects by promoting GLUT4 activation through upregulation of the IRS-1/PI3K/Akt signaling pathway and activating adenosine monophosphate-activated kinase/acetyl-CoA carboxylase (AMPK/ACC) signaling, respectively, as shown in diabetic rats by triterpenoids in Stauntonia chinensis (Xu et al., 2018). In addition, Triterpenoid saponins in *S. lasiocarpum* fruit extract may reduce plasma glucose levels by enhancing insulin secretion through modulation of VDCCs, thereby promoting glycogenesis and cellular regeneration, as reported for triterpenoids in *S. lasiocarpum* (Singh et al., 2014) and *Momordica cymbalaria* Fenzl (Koneri et al., 2014).

Alkaloids have been reported to possess antidiabetic properties (Al-Ashaal et al., 2018). Although alkaloids have been identified in *S. lasiocarpum* fruit extract, there is limited literature addressing their specific antidiabetic effects in *Solanum* species. Nevertheless, alkaloids in *S. lasiocarpum* fruit extract may contribute to the reduction of blood glucose levels, as demonstrated by the alkaloid of *Aerva lanata* in diabetic rat models (Agrawal et al., 2013). This effect may be mediated through the inhibition of α-amylase and α-glucosidase activities, as reported for alkaloids from *S. melongena* (Asano et al., 1997). In addition, alkaloids from *S. lasiocarpum* fruit extract may enhance glucose uptake via inhibition of protein tyrosine phosphatase-1B (PTP-1B), a key negative regulator of insulin receptor signaling (Kwon et al., 2008). Similar mechanisms have been observed in C2C12 skeletal muscle cells with alkaloids derived from *Veratrum nigrum* (Kang et al., 2015), as well as in pancreatic β-TC6 cells and other models involving alkaloids from *Catharanthus roseus* (Tiong et al., 2013).

Blood Profile

The measurement results of blood profiles (erythrocytes, hemoglobin, platelets, and leukocytes) after treatment can be seen in Table 2.

Table 2 Blood Profile Qualification

Group	Erythrocyte (10^6/µL)	Hemoglobin (g/dL)	Leukocyte (10^3/µL)	Platelets (10^3/µL)	*p-value*
G1	9,34 ± 0,33^{f}	16,25 ± 0,54^{f}	10,54 ± 0,22^{a}	370,80 ± 20,40^{a}	0,000
G2	4,25 ± 0,14^{a}	10,22 ± 0,19^{a}	21,35 ± 1,17^{e}	1050,20 ± 45,84^{f}	
G3	8,86 ± 0,11^{e}	15,66 ± 0,16^{e}	11,47 ± 0,30^{ab}	536,40 ± 23,95^{b}	
G4	5,04 ± 0,14^{b}	11,82 ± 0,48^{b}	17,86 ± 0,14^{d}	952,40 ± 61,50^{e}	
G5	5,60 ± 0,23^{c}	12,64 ± 0,24^{c}	15,96 ± 1,55^{c}	754,20 ± 21,28^{d}	
G6	6,57 ± 0,33^{d}	14,51 ± 0,36^{d}	12,13 ± 0,49^{b}	636,00 ± 24,16^{c}	

Description: The value shows the average ± standard deviation (n=5). G1: normal control; G2: diabetic control; G3: metformin control; G4: extract 200 mg/kg BW; G5: extract 300 mg/kg BW; and G6: extract 400 mg/kg BW. Different superscript letters (a–f) within the same column indicate statistically significant differences between groups ($p < 0.05$).

The results showed that the average number of erythrocytes and hemoglobin in the G2 group as a control for alloxan-induced diabetes was lower when compared to the average of the G1 group (normal control). These resuls are consistent with previous studies reporting a reduction in erythrocyte count and hemoglobin levels in alloxan-induced rats

After 14 days of extract administration, erythrocyte counts showed a highly significant increase ($p < 0.05$) compared to the G2 group (Table 2). This

increase in erythrocyte count was concomitant with a reduction in blood glucose levels. The G2 group exhibited the lowest erythrocyte count. In contrast, groups G4, G5, and G6, which received the extract, demonstrated a highly significant increase ($p < 0.05$). The highest erythrocyte count among the treated groups was observed in G6, followed by G5 and G4, all of which showed marked improvements.

After 14 days of treatment, hemoglobin concentrations were significantly elevated ($p < 0.05$) relative to the G2 group (Table 2), in parallel with decreases in blood glucose levels. Significant increases in hemoglobin levels were likewise observed in groups G4, G5, and G6 ($p < 0.05$). The G2 group exhibited the lowest hemoglobin level. In contrast, the highest hemoglobin level among extract-treated groups was observed in G6, while G4 and G5 also demonstrated increased values. Following 14 days of administration of *S. lasiocarpum* fruit extract, both erythrocyte count and hemoglobin levels increased, approaching values comparable to those of the normal control group (G1). The group that most closely approximated G1 was G6, which received the highest dose of 400 mg/kg BW.

The results indicated that the mean leukocyte and platelet counts in the G2 group (alloxan-induced diabetic control) were higher than those in the G1 group (normal control). These findings are consistent with previous studies reporting increased leukocyte and platelet counts in alloxan-induced rats (Osigwe et al., 2017).

After 14 days of extract administration, the leukocyte count showed a highly significant decrease ($p < 0.05$) compared to the G2 group (Table 2). This reduction in leukocyte levels was consistent with the observed decrease in blood glucose levels. The G2 group exhibited the highest leukocyte count. In contrast, the treatment groups (G4, G5, and G6) showed a significant reduction ($p < 0.05$) following extract administration. Among these, the lowest leukocyte count was observed in the G6 group, followed by G5 and G4.

After 14 days of extract administration, platelet counts decreased significantly ($p < 0.05$) compared with the G2 group (Table 2). This reduction in platelet count was consistent with the observed decrease in blood glucose levels. Furthermore, platelet counts in groups G4, G5, and G6 also showed statistically significant reductions ($p < 0.05$). The G2 group exhibited the highest platelet count. In contrast, the lowest platelet count among the extract-treated groups was observed in G6, while platelet counts in G4 and G5 respectively. Overall, administration of *S. lasiocarpum* fruit extract for 14 days resulted in reductions in both leukocyte and platelet counts, approaching values comparable to those of the normal control group (G1). The G6 group, which received the highest dose (400 mg/kg BW), demonstrated the closest approximation to the normal control values.

Changes in hematological and immune system parameters during diabetes have been extensively studied (Mansi & Lehham, 2008). In addition, toxicological studies have shown that the consumption of medicinal plants or pharmaceutical agents may alter normal hematological values (Ajagbonna et al., 1999). Therefore, hematological parameters serve as important indicators for evaluating both the effects of diabetes and the potential impact of medicinal plant extracts. Anemia is a common pathophysiological feature and complication of diabetes mellitus (Kothari & Bokariya, 2012). It has been associated with increased non-enzymatic glycosylation of red blood cell (RBC) membrane proteins under hyperglycemic conditions (Oyedemi et al., 2011).

Under chronic hyperglycemia in uncontrolled diabetes mellitus, oxidation of these membrane proteins enhances lipid peroxidation, which contributes to hemolysis of red blood cells (Shenoy & Goyal, 2002). One of the pathological consequences of membrane lipid peroxidation is reduced erythrocyte survival (Kolanjiappan et al., 2002). Although lipid peroxide levels in red blood cell membranes were not measured in the present study, other hematological parameters, such as hemoglobin, were assessed to evaluate the effect of *S. lasiocarpum* fruit extract on the anemia status of diabetic rats.

A decrease in RBC count and related indices following treatment with diabetogenic agents in experimental models is indicative of impaired and abnormal erythropoiesis. This finding is consistent with previous reports by Mahmoud (2013) and Chinonye et al. (2014). Administration of *S. lasiocarpum* fruit extract to alloxan-induced diabetic rats significantly increased RBC levels and their indices ($p < 0.05$). This effect suggests that certain phytoconstituents in the extract may stimulate the production or secretion of erythropoietin, a hormone that promotes the differentiation of stem cells in the bone marrow into red blood cells (Ohlsson & Sm, 2010). Phytochemicals such as flavonoids (Usman & Osuji, 2007) present in *S. lasiocarpum* fruit extract may be responsible for this effect. Similarly, Mahmoud (2013) reported that grape flavonoids increase RBCs and indices in diabetic rats, which may be attributed to their ability to lower lipid peroxidation levels, thereby minimizing oxidative damage and preventing erythrocyte hemolysis.

White blood cells (WBCs) play a crucial role in eliminating foreign substances. The number of WBCs is known to increase as part of the body's defense mechanism in response to toxic conditions (Agbor et al., 2005). Alterations in WBC levels have been associated with insulin resistance and cardiovascular complications (Mohammed et al., 2013). Leukocytosis has been linked to insulin resistance, type 2 diabetes mellitus, coronary artery disease, stroke, and microangiopathy (Mahmoud et al., 2013). Leukocyte activation is reported to be

induced by advanced glycation end products (AGEs), oxidative stress, angiotensin II, and pro-inflammatory cytokines (Mahmoud et al., 2013). In the present study, a significant increase ($p < 0.05$) in WBC count was observed in the diabetic control group, whereas treatment with *S. lasiocarpum* fruit extract resulted in a significant, dose-dependent reduction ($p < 0.05$). This effect may be attributed to the extract's ability to improve insulin sensitivity, reduce the formation of AGEs, and alleviate oxidative stress in blood cells. These findings are consistent with previous reports (Osigwe et al., 2017).

Platelet count has been reported to be significantly higher in diabetic individuals compared to non-diabetics, with a positive correlation between platelet count and poor glycemic control (Isaac IZ, 2012). Increased platelet counts may contribute to vascular complications in patients with insulin resistance (Taniguchi et al., 2003). In addition, platelet count is positively correlated with leukocyte count, suggesting a shared underlying mechanism (Jesri et al., 2005). Elevated platelet levels are commonly observed in inflammatory and infectious conditions (Williams et al., 1983) and are considered part of the acute-phase response to inflammation or infection, such as in alloxan-induced diabetes mediated by free radical generation (Edet et al., 2013). In the present study, thrombocytosis was observed in untreated diabetic control rats. However, treatment with *S. lasiocarpum* fruit extract resulted in a significant, dose-dependent reduction ($p < 0.05$) in platelet count. These findings suggest that the extract may contribute to improved glycemic control and provide protective effects against diabetes-associated vascular complications.

SGPT and SGOT Levels

Hepatocellular injury can be identified by elevated serum levels of SGOT (serum glutamate oxaloacetate transaminase) and SGPT (serum glutamate pyruvate transaminase), which serve as key biochemical markers of liver function. SGPT and SGOT are two transaminase enzymes produced by liver cells. An increase in SGPT and SGOT indicates liver cell damage compared to other liver enzymes because both enzymes will increase first if liver cells are damaged.

The measurement of SGPT and SGOT levels in this study was carried out to determine liver function after alloxan induction and treatment. The measurement results can be seen in the Table 3.

Table 3 SGPT and SGOT Levels

Group	SGOT Rate (U/L)	SGPT Rate (U/L)	*p-value*
G1	137,00 ± 4,95[a]	75,00 ± 3,67[a]	0,000
G2	255,80 ± 17,33[d]	185,20 ± 5,26[e]	
G3	145,20 ± 3,63[a]	77,60 ± 1,67[a]	
G4	192,60 ± 6,88[c]	125,60 ± 4,83[d]	
G5	168,40 ± 4,72[b]	109,60 ± 6,95[c]	
G6	163,60 ± 2,30[b]	84,80 ± 6,38[b]	

Description: The value shows the average ± standard deviation (n=5). G1: normal control, G2: diabetes control, G3: metformin control, G4: extract dose 200 mg/kg BW, G5: extract dose 300 mg/kg BW, and G6: extract dose 400 mg/kg BW. The number followed by different letters in one column shows a real difference ($p<0.05$).

The results showed that the average levels of SGOT and SGPT levels in the G2 group (alloxan-induced diabetic control) were higher than those in the G1 group (normal control). This finding is consistent with previous studies reporting elevated SGOT and SGPT levels in alloxan-induced diabetic rats (Balamurugan et al., 2014; Fard et al., 2015; Farokhi et al., 2011; Mansour et al., 2002; Agila & Kavitha, 2012; Osigwe et al., 2017).

After 14 days of extract administration, SGOT levels showed a highly significant decrease ($p < 0.05$) compared to the G2 group (Table 3). This reduction was consistent with the observed decrease in blood glucose levels. The G2 group exhibited the highest SGOT level. In contrast, the treatment groups (G4, G5, and G6) showed a significant reduction ($p < 0.05$) following extract administration. The lowest SGOT level was observed in the G6 group, followed by G5 and G4.

After 14 days of extract administration, SGPT levels showed a highly significant decrease ($p < 0.05$) compared to the G2 group (Table 3). This reduction was consistent with the observed decrease in blood glucose levels. The results indicated that the treatment groups (G4, G5, and G6) exhibited a significant decrease ($p < 0.05$) in SGPT levels following extract administration. The G2 group showed the highest SGPT level. In contrast, the lowest SGPT level was observed in the G6 group, followed by G5 and G4. Overall, after 14 days of administration of *S. lasiocarpum* fruit extract, SGOT and SGPT levels decreased and were almost close to the same values as the normal control group (G1). The G6 group, which received *S. lasiocarpum* fruit extract at a dose of 400 mg/kg BW, demonstrated the most substantial reduction in SGOT and SGPT levels, with values approaching those of the G1 (normal control) group.

The liver plays a central role in maintaining plasma glucose levels within a narrow physiological range (Yamatani et al., 1994). In alloxan-induced diabetic models, increased toxicity mediated by free radicals has been widely reported. Hyperglycemia can disrupt cellular redox balance, particularly in the liver, leading to oxidative stress (Zafar et al., 2009). Excessive free radical production depletes antioxidant defenses, resulting in impaired cellular function. Experimental studies have also demonstrated a reduction in liver weight in diabetic animals, which may be attributed to enhanced glycogenolysis, increased protein degradation, and elevated gluconeogenesis (Çoruh et al., 2007).

Serum glutamate pyruvate transaminase (SGPT) and serum glutamate oxaloacetate transaminase (SGOT) are key enzymes involved in amino acid metabolism, specifically in the conversion of amino acids to keto acids

(Khaki et al., 2008; Parmar, 1982). The activities of SGPT and SGOT are commonly used as biochemical markers of hepatocellular damage. In the early stages of liver injury, these cytoplasmic enzymes leak from hepatocytes into the bloodstream (Parmar, 1982). The observed elevation of SGOT and SGPT levels in diabetic control rats may therefore be attributed to hepatocellular damage induced by alloxan toxicity, as liver injury is often associated with increased serum levels of these enzymes (Osigwe et al., 2017). However, it has also been reported that SGPT plays a role in gluconeogenesis and that its transcription is regulated by insulin. Consequently, increased SGPT activity may reflect impaired insulin signaling rather than direct hepatocellular injury (Togenu et al., 2015).

The observed decrease in SGOT and SGPT levels may be attributed to the hepatoprotective and antioxidant properties of *S. lasiocarpum* fruit extract. Antioxidants are known to mitigate the progression of chemically induced liver damage by neutralizing free radicals (Chen, 2007). Thus, the antioxidant constituents present in *S. lasiocarpum* fruit likely contributed to the reduction of hepatic injury. Furthermore, increased serum protein levels may also indicate hepatoprotective activity, as enhanced protein synthesis supports hepatocyte regeneration and restoration of liver function (Hassan & Ladan, 2010). The normalization of SGPT and SGOT levels following treatment with metformin and *S. lasiocarpum* fruit extract further supports the antidiabetic and hepatoprotective potential of the extract. Since SGPT and SGOT are important biomarkers of liver function, their return to near-normal levels suggests an improvement in hepatic integrity and function. These findings are consistent with previous studies, such as Agila and Kavitha (2012), which demonstrated that antioxidant-rich plant extracts, including *Pterocarpus marsupium*, can significantly reduce SGOT and SGPT levels in alloxan-induced diabetic rats.

Creatinine and Ureum Levels

Creatinine is a metabolic waste product derived from the breakdown of creatine in muscle tissue, which is utilized during muscle contraction. Creatine is produced by creatine, which is an important molecule in muscles that functions to produce energy. Before being excreted from the body through urine, creatine must first be filtered by the kidneys. The concentration level of creatinine in serum should not change if kidney function is working properly.

Ureum is a chemical compound that indicates normal kidney function. Therefore, a urea test is always used to see kidney function suspected of having a disorder in the kidney organ. If it is known that the urea in urine decreases, it will result in a decrease in the glomerular filtration rate (kidney filtration function). This decrease makes urea increase in the blood. The measurement of creatinine and urea levels in this study was conducted to evaluate renal function following alloxan induction and treatment with *S. lasiocarpum* fruit extract. The results of these measurements are presented in Table 4.

Table 4 Creatinine and Urea levels

Group	Creatinine levels (mg/dL)	Ureum Levels (mg/dL)	*p-value*
G1	0,50 ± 0,08^{a}	27,20 ± 0,84^{a}	0,000
G2	1,46 ± 0,01^{e}	72,60 ± 5,68^{f}	
G3	0,58 ± 0,02^{ab}	31,20 ± 1,30^{b}	
G4	0,99 ± 0,12^{d}	54,40 ± 1,82^{e}	
G5	0,74 ± 0,02^{c}	43,40 ± 1,34^{d}	
G6	0,65 ± 0,03^{b}	36,40 ± 1,14^{c}	

Description: The value shows the average ± standard deviation (n=5). G1: normal control; G2: diabetic control; G3: metformin control; G4: extract 200 mg/kg BW; G5: extract 300 mg/kg BW; and G6: extract 400 mg/kg BW. Different superscript letters (A–F) within the same column indicate statistically significant differences between groups ($p < 0.05$).

The results showed that the average levels of creatinine and urea in the G2 group as a control for alloxan-induced diabetes were higher when compared to the average of the G1 group (normal control). This result is in line with several studies that have reported that there is an increase in creatinine and urea levels in alloxane-induced mice (Balamurugan et al., 2014; Mansour et al., 2002; Osigwe et al., 2017).

Creatinine levels after 14 days of extract administration showed a highly significant decrease ($p < 0.05$) compared to the G2 group (Table 4). This reduction in creatinine levels was consistent with the observed decrease in blood glucose levels. The G2 group exhibited the highest creatinine level. In contrast, the treatment groups (G4, G5, and G6) demonstrated a significant decrease ($p < 0.05$) following the administration of the extract. The lowest creatinine levels in the rat group given the extract were G6, while the creatinine levels of G4, and G5.

Ureum levels after 14 days of extract administration showed a highly significant decrease ($p < 0.05$) compared to the G2 group (Table 4). A decrease in urea levels was consistent with the observed reduction in blood glucose levels. The measurement of urea levels in the G4, G5, and G6 groups showed a significant decrease ($p < 0.05$). The lowest urea level among the extract-treated groups was observed in G6, while the urea levels of G4 and G5 were the lowest urea levels in the group given the extract.

Overall, following 14 days of *S. lasiocarpum* fruit extract administration, creatinine and urea levels decreased and approached those of the normal control group (G1). The most pronounced reduction, with values closest to the G1 group, was observed in the G6 group, which received *S. lasiocarpum* fruit extract at a dose of 400 mg/kg BW.

The kidneys serve as the primary excretory organs, and renal function tests are essential for detecting potential kidney damage. Elevated serum urea

and creatinine levels are among the most sensitive indicators of renal impairment. In the present study, urea and creatinine levels were significantly increased ($p < 0.05$) in diabetic mice, indicating compromised kidney function. This elevation is commonly associated with hyperglycemia. Ekakitie and Ajiboye (2021) reported that alloxan-induced hyperglycemia leads to increased urea and creatinine levels. The elevated serum urea observed in diabetic control animals may be attributed to enhanced gluconeogenesis as an alternative source of glucose under conditions of insulin deficiency. This process is supported by increased proteolysis, which releases glucogenic amino acids that subsequently undergo deamination in the liver, resulting in elevated urea levels (Abdulazeez et al., 2013).

The 14-day administration of *S. lasiocarpum* fruit extract resulted in a significant, dose-dependent reduction in this parameter ($p < 0.05$). The normalization of this index suggests an improvement in renal function, which may be attributed to the extract's antihyperglycemic effects. These effects likely enhance insulin activity, thereby reducing proteolysis. This finding is consistent with the study reported by Ekakitie and Ajiboye (2021). According to research by Ekakitie & Ajiboye (2021), *Solanum macrocarpon* leaf water extract has anti-inflammatory activities by suppressing IL-2 and TNF-α. The extract also contains antioxidants.

This may also apply to the fruit extract of *S. lasiocarpum* employed in this investigation. Furthermore, persistent impairments in kidney function result in changes in renal hemodynamics. This causes proteinuria, glomerulosclerosis, and eventually kidney failure. A study by Dasgupta et al. (2016) found that nitrogen imbalance, along with decreased protein synthesis, leads to the creation of non-protein nitrogenous compounds. In diabetic nephropathy, creatinine and urea levels are elevated. Increased creatinine and ureum levels in diabetic control mice favored renal injury, Serum creatinine and urea levels are considered crucial indicators of diabetic nephropathy (Kamble & Bodhankar, 2013). In the present study, oral administration of *S. lasiocarpum* fruit extract improved impaired renal function, as evidenced by reductions in serum creatinine and urea levels. These findings further support the anti-nephropathic potential of the extract.

The underlying mechanism may be attributed to its ability to enhance the production of endogenous enzymatic and non-enzymatic antioxidants, thereby facilitating the effective clearance of mitochondrial reactive oxygen species (ROS). This antioxidative action may contribute to the observed reduction in serum creatinine and urea levels. Similar findings have been reported by Ekakitie and Ajiboye (2021), who demonstrated that aqueous extracts of *Solanum macrocarpon* leaves significantly reduced serum creatinine and urea levels.

Conclusion

The administration of *Solanum lasiocarpum* (eggplant) fruit extract to alloxan-induced diabetic rats resulted in a reduction in blood glucose levels and an increase in erythrocyte count and hemoglobin levels. Additionally, the extract significantly decreased platelet and leukocyte counts, as well as SGPT, SGOT, creatinine, and ureum levels. These findings indicate its potential in ameliorating hematological, hepatic, and renal alterations associated with diabetes. The most effective dose in minimizing the effects of diabetes was 400 mg/kg body weight.

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References

Abdulazeez, M., Kassim, I., Kenpia, B., Hope, B., & Yusuf, A. (2013). Effect of combined use of Ocimum gratissimum and Vernonia amygdalina extract on the activity of angiotensin converting enzyme, hypolipidemic and antioxidant parameters in streptozotocin-induced diabetic rats. *African Journal of Biochemistry Research, 7*(9), 165–173. https://doi.org/10.5897/AJBR12.091

Afiqoh, A. N., Fidianingsih, I., & Handayani, E. S. (2017). Pengaruh Pemberian Ekstrak Etanol Daun Pegagan (*Centella asiatica*) terhadap Gambaran Histopatologi Limpa Tikus (*Rattus norvegicus*) yang diinduksi Sodium Nitrit Sub Akut. *JK Unila, 1*, 457–462. https://doi.org/10.23960/jkunila.v1i3.pp457-462

Agbor, G. A., Oben, J. E., & Ngogang, J. Y. (2005). Haematinic activity of Hibiscus cannabinus. *African Journal of Biotechnology, 4*(8), 833–837. https://doi.org/10.4314/ajb.v4i8.15192

Agila, K. N., & Kavitha, R. (2012). Antidiabetic, Antihyperlipidaemic and Antioxidant Activity of Oxalis corniculata in Alloxan Induced Diabetic Mice. *Journal of Natural Sciences Research*, *2*(7), 2224-3186. https://iiste.org/Journals/index.php/JNSR/article/view/2760

Agrawal, R., Sethiya, N. K., & Mishra, S. H. (2013). Antidiabetic activity of alkaloids of Aerva lanata roots on streptozotocin-nicotinamide induced type-II diabetes in rats. *Pharmaceutical Biology*, *51*(5), 635–642. https://doi.org/10.3109/13880209.2012.761244

Ajagbonna, O. P., Onifade, K. I. and S. (1999). Hematological and Bio- chemical Changes in Rats Given Extract of Calotropis procera. *Sokoto Journal of Veterinary Sciences*, *1*, 36–42.

https://www.sokvetjournal.net/

Al-Ashaal, H. A. A. H., Farghaly, A. A., & Abdel-Samee, N. S. (2018). Antidiabetic efficacy of solanum torvum extract and glycoalkaloids against diabetes induced mutation in experimental animals. *Journal of Pharmaceutical Sciences and Research*, *10*(6), 1323–1331. https://www.researchgate.net/publication/326395008_Antidiabetic_efficacy_of_solanum_torvum_extract_and_glycoalkaloids_against_diabetes_induced_mutation_in_experimental_animals

Amjad, S., Jafri, A., Sharma, A. K., & Serajuddin, M. (2019). A novel strategy of nanotized herbal drugs and their delivery in the treatment of diabetes: Present status and future prospects. *Journal of Herbal Medicine*, *17–18*(November 2016), 100279. https://doi.org/10.1016/j.hermed.2019.100279

Asano, N., Kato, A., Matsui, K., Watson, A. A., Nash, R. J., Molyneux, R. J., Hackett, L., Topping, J., & Winchester, B. (1997). The effects of calystegines isolated from edible fruits and vegetables on mammalian liver glycosidases. *Glycobiology*, *7*(8), 1085–1088. https://doi.org/10.1093/glycob/7.8.1085

Balamurugan, K., Nishanthini, A., & Mohan, V. R. (2014). Antidiabetic and antihyperlipidaemic activity of ethanol extract of *Melastoma malabathricum* Linn. leaf in alloxan induced diabetic rats. *Asian Pacific Journal of Tropical Biomedicine*, *4*(Suppl 1), S442–S448. https://doi.org/10.12980/APJTB.4.2014C122

Barbosa, A. P., Dde Oliveira Silveira, G., De Menezes, I. A. C., Rezende Neto, J. M., Bitencurt, J. L. C., Estavam, C. D. S., De Lima, A. D. C. B., Thomazzi, S. M., Guimarães, A. G., Quintans-Junior, L. J., & Dos Santos, M. R. V. (2013). Antidiabetic effect of the Chrysobalanus icaco L. aqueous extract in rats. *Journal of Medicinal Food*, *16*(6), 538–543. https://doi.org/10.1089/jmf.2012.0084

Bilous, R., & Donelly, R. (2015). *Buku Pegangan Diabetes Edisi Ke-4*. Bumi Medika.

Cazarolli, L. H., Zanatta, L., Alberton, E. H., Figueiredo, M. S. R. B., Bonorino Figueiredo, M., Folador, P., Damazio, R. G., Pizzolatti, M. G., & Silva, F. R. M. B. (2008). Flavonoids: Cellular and Molecular Mechanism of Action in Glucose Homeostasis. *Mini-Reviews in Medicinal Chemistry*, *8*(10), 1032–1038. https://doi.org/10.2174/138955708785740580

Chen, H. (2007). Antioxidant activity and free radical-scavenging capacity of extracts from guava (*Psidium guajava* L.) leaves. *Food Chemistry*, *101(2)*, 686–694. https://doi.org/10.1016/j.foodchem.2006.02.047

Chinonye, A. S., Ikechukwu, O. A., & Nnah, S. (2014). Glucose Level, Haematological Parameters and Lipid Profile in Ficus Sur Treated Diabetic Rats. *Comprehensive Journal of Agricultural and Biological Science*, *2*(1), 5–11. https://www.researchgate.net/publication/308050748_GLUCOSE_LEVEL_HAEMATOLOGICAL_PARAMETERS_AND_LIPID_PROFILE_IN_FICUS_SUR_TREATED_DIABETIC_RATS

Çoruh, N., Celep, A. G. S. ̈diçog ̆lu, & Özgökçe, F. (2007). Antioxidant properties of Prangos ferulacea (L.) Lindl., Chaerophyllum macropodum Boiss. and Heracleum persicum Desf. from Apiaceae family used as food in Eastern Anatolia and their inhibitory effects on glutathione-S-transferase. *Food Chemistry*, *100*(3), 1237–1242. https://doi.org/10.1016/j.foodchem.2005.12.006

Dasgupta, N., Muthukumar, S. P. & Murthy, P. S. (2016). Solanum nigrum leaf: natural food against diabetes and its bioactive compounds. *Research Journal of Medicinal Plant*, *10*(2), 181–193. https://scialert.net/abstract/?doi=rjmp.2016.181.193

Edet, A. E., Patrick, E. E., & Olorunfemi, A. (2013). Hematological Parameters of Alloxan-Induced Diabetic Rats Treated With Ethanol Extracts and Fractions of Nauclea Lafiloia Leaf. *European Scientific Journal*, *9*(27), 1857–7881. https://doi.org/10.19044/ESJ.2013.V9N27P%P

Ekakitie, L., Ajiboye, B. O., Oyinloye, B. E., Owero-ozeze, O. S., Onikanni, S. A., & Ojo, O. A. (2021). Attenuation of diabetic nephropathy in alloxan-induced diabetic rats by Solanum macrocarpon Linn aqueous leaves extract. *Comparative Clinical Pathology*, 30, 173–179. https://doi.org/10.1007/s00580-021-03220-5?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle

Elekofehinti, O. O., Kamdem, J. P., Kade, I. J., Rocha, J. B. T., & Adanlawo, I. G. (2013). South African Journal of Botany Hypoglycemic, antiperoxidative and antihyperlipidemic effects of saponins from Solanum anguivi Lam. fruits in alloxan-induced diabetic rats. *South African Journal of Botany*, *88*, 56–61. https://doi.org/10.1016/j.sajb.2013.04.010

Fard, M. H., Naseh, G., Lotfi, N., Mahmoud, S., & Hosseini, M. (2015). Effects of aqueous extract of turnip leaf (Brassica rapa) in alloxan- induced diabetic rats. *Avicenna Journal of Phytomedicine*. *5*(2), 148–156. https://pmc.ncbi.nlm.nih.gov/articles/PMC4418064/

Farokhi, F., Farkhad, N. K., & Togmechi, A. (2011). Preventive effects of Prangos ferulacea (L .) Lindle on liver damage of diabetic rats induced by alloxan. *Avicenna Journal of Phytomedicine*, *2*(2), 63–71. https://pmc.ncbi.nlm.nih.gov/articles/pmid/25050232/

Fox, C., & Kilvert, A. (2010). *Bersahabat dengan Diabetes*

Melitus Tipe 1. Penerbar Plus+.

Hassan, S. W., Salawu, K., Ladan, M. J., Hasan, L. G., Umar, R. A., & Fatihu, M. Y. (2010). Hepatoprotective, Antioxidant and Phytochemical Properties of Leaf Extracts of Newbouldia Laevies. *International Journal of Pharm Tech Research*, 2(1), 573-584. http://sphinxsai.com/sphinxsaiVol_2No.1/PharmTech_Vol_2No.1/PharmTech_Vol_2No.1PDF/PT=91%20%20(573-584).pdf

Hwong, C-S., Koh, C., & Hii, S-L. (2018). Nutritional Compotition of Unripe and Ripe Freeze-Dried Terung Asam From Serawak. *Jornal Of Social Science and Humanities*, 16(3), 1-6. http://journalarticle.ukm.my/19539/

IDF. (2019). *Idf Diabetes Atlas (9th ed.)*. https://www.diabetesatlas.org/en/resources/

Isaac IZ, E. O. (2012). Some Haematological Parameters in Patients with Type-1 Diabetes in Sokoto, North Western Nigeria. *Journal of Blood & Lymph*, *03*(01), 14–18. https://doi.org/10.4172/2165-7831.1000110

Jesri, A., Okonofua, E. C., & Egan, B. M. (2005). Platelet and white blood cell counts are elevated in patients with the metabolic syndrome. *Journal of Clinical Hypertension (Greenwich, Conn.)*, *7*(12), 705–711. https://doi.org/10.1111/j.1524-6175.2005.04809.x

Kamble, H. V., & Bodhankar, S. L. (2013). Antihyperglycemic activity of trigonelline and sitagliptin in nicotinamide-streptozotocin induced diabetes in Wistar rats. *Biomedicine and Aging Pathology*, *3*(3), 125–130. https://doi.org/10.1016/j.biomag.2013.05.006

Kang, C. H., Han, J. H., Oh, J., Kulkarni, R., Zhou, W., Ferreira, D., Jang, T. S., Myung, C. S., & Na, M. K. (2015). Steroidal alkaloids from Veratrum nigrum enhance glucose uptake in skeletal muscle cells. *Journal of Natural Products*, *78*(4), 803–810. https://doi.org/10.1021/np501049g

Kelly, C., Flatt, C. C. S., & McClenaghan, N. H. (2011). Stem cell-based approaches for the treatment of diabetes. *Stem Cells International*, *2011*. https://doi.org/10.4061/2011/424986

Kemenkes. (2020). *Kemenkes Sarankan Masyarakat Manfaatkan Obat Tradisional*. https://www.kemkes.go.id/article/view/20052100005/kemenkes-sarankan-masyarakat-manfaatkan-obat-tradisional.html

Kemenkes. (2018). *Laporan Nasional RISKESDAS 2018*. Kementrian Kesehatan RI, Badan Penelitian dan Pengembangan Kesehatan. https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/Laporan%20Riskesdas%202018%20Nasional.pdf

Khaki, A. A., Khaki, A., Nouri, M., Ahmadi-Ashtiani, H. R., Rastegar, H., Rezazadeh, S. H., Fathiazad, F., & G. (2008). Evaluation Effects of Quercetin on Liver Apoptosis in Streptozotocin- induced Diabetic Rat. *Journal of Medicinal Plants*, *8*(5), 70–78. https://www.researchgate.net/publication/287877431_Evaluation_Effects_of_Quercetin_on_Liver_Apoptosis_in_Streptozotocin_induced_Diabetic_Rat

Kolanjiappan, K., Manoharan, S., & Kayalvizhi, M. (2002). Measurement of erythrocyte lipids, lipid peroxidation, antioxidants and osmotic fragility in cervical cancer patients. *Clinica Chimica Acta*, *326*(1–2), 143–149. https://doi.org/10.1016/S0009-8981(02)00300-5

Koneri, R. B., Samaddar, S., Ramaiah, C. (2014). Antidiabetic Activity of a Triterpenoid Saponin Isolated from Momordica Cymbalaria Fenzl. *Indian Journal of Experimental Biologi*, *52*, 46–52. https://pubmed.ncbi.nlm.nih.gov/24624483/

Kothari, R., & Bokariya, P. (2012). A comparative study of haematological parameters in type 1 diabetes mellitus patients and healthy young adolescents. *Int J Biol Med Res*, *3*(4), 2429–2432. https://search.crossref.org/?from_ui=&q=0976-6685

Kwon, Y. I., Apostolidis, E., & Shetty, K. (2008). In vitro studies of eggplant (Solanum melongena) phenolics as inhibitors of key enzymes relevant for type 2 diabetes and hypertension. *Bioresource Technology*, *99*(8), 2981–2988. https://doi.org/10.1016/j.biortech.2007.06.035

Mahmoud, A. M., Ahmed, O. M., Abdel-Moneim, A., & Ashour, M. B. (2013). Upregulation of PPAR γ mediates the antidiabetic effects of citrus flavonoids in type 2 diabetic rats. *International Journal of Bioassays, 2(5),* 756-761. https://www.ijbio.com/abstract/upregulation-of-ppar-mediates-the-antidiabetic-effects-of-citrus-flavonoids-in-type-2-diabetic-rats-13738.html

Mahmoud, A. M. (2013). Original article : Hematological Alterations In Diabetic Rats - Role Of Adipocytokines And Effect Of Citrus Flavonoids. *EXCLI Journal*, 12, 647–657. https://pmc.ncbi.nlm.nih.gov/articles/PMC4778348/

Mansi, K., & Lehham, J. (2008). Effects of Artemisia sieberi Bessa a Herba-Alba on Heart Rate and Some Hematological Values in Normal and Alloxan-Induced Dia- betic Rats. *Journal of Basic and Applied Sciences*, *4*, 57-72. https://www.researchgate.net/publication/228632814_Effects_of_Artemisia_sieberi_besser_A_herba-alba_on_heart_rate_and_some_hematological_values_in_normal_and_alloxan-induced_diabetic_rats

Mansour, H. A., Newairy, A. A., & Yousef, M. I. (2002). Biochemical study on the effects of some Egyptian

herbs in alloxan-induced diabetic rats. *Toxicology*, 170(3), 221–228. https://doi.org/10.1016/s0300-483x(01)00555-8

Mohammed, R. K., Ibrahim, S., Atawodi, S. E., Eze, E. D., Suleiman, J. B., Ugwu, M. N., & Malgwi, I. S. (2013). Anti-diabetic and haematological effects of n-butanol fraction of alchornea cordifolia leaf extract in streptozotocin-induced diabetic wistar rats. *Scientific Journal of Biological Sciences*, *2*(3), 45–53. www.Sjournals.com

Nguyen, P. H., Tuan, H. N., Hoang, D. T., Vu, Q. T., Pham, M. Q., Tran, M. H., & To, D. C. (2019). Glucose Uptake Stimulatory and PTP1B Inhibitory Activities of Pimarane Diterpenes from Orthosiphon stamineus Benth. *Biomolecules*, 9(12), 859. https://doi.org/10.3390/biom9120859

Ohlsson, A., & Aher, S. M. (2016). Early erythropoietin for preventing red blood cell transfusion in preterm and/or low birth weight infants. *Cochrane Database of Systematic Reviews*. 2014(4), 1-88. https://doi.org/10.1002%2F14651858.CD004863.pub4

Osigwe, C. C., Akah, P. A., & Nworu, C. S. (2017). Biochemical and Haematological Effects of the Leaf Extract of Newbouldia laevis in Alloxan-Induced Diabetic Rats. *Journal of Biosciences and Medicines, 5*, 18–36. https://doi.org/10.4236/jbm.2017.56003

Oyedemi, O. O., Adewusi, E. A., Aiyegoro, O. A., & Akinpelu, D. A. (2011). Antidiabetic and haematological effect of aqueous extract of stem bark of Afzelia africana (Smith) on streptozotocin-induced diabetic Wistar rats. *Asian Pacific Journal of Tropical Biomedicine*, *1*(5), 353–358. https://doi.org/10.1016/S2221-1691(11)60079-8

Park, H., & Kim, H. S. (2014). Korean traditional natural herbs and plants as immune enhancing, antidiabetic, chemopreventive, and antioxidative agents: A narrative review and perspective. *Journal of Medicinal Food*, *17*(1), 21–27. https://doi.org/10.1089/jmf.2013.3059

Parmar, C., K. M. K. (1982). *Aeglemarmelos Wild Fruits*. Kalyani Publishers.

Rehman, G., Hamayun, M., Iqbal, A., Ul Islam, S., Arshad, S., Zaman, K., Ahmad, A., Shehzad, A., Hussain, A., & Lee, I. (2018). In vitro antidiabetic effects and antioxidant potential of cassia nemophila pods. *BioMed Research International*, 2018, 1-6. https://doi.org/10.1155/2018/1824790

Rohilla, A., & Ali, S. (2012). Alloxan Induced Diabetes : Mechanisms and Effects. *International Journal of Research in Pharmaceutical and Biomedical Science*, *3*(2), 819–823. https://doi.org/10.12691/ajphr-7-6-5

Shenoy, A. G., & Goyal, R. K. (2002). Improvement of insulin sensitivity by perindopril in spontaneously hypertensive and streptozotocin-diabetic rats. *Indian Journal of Pharmacology*, *34*(3), 156–164. https://www.researchgate.net/publication/286971418_Improvement_of_insulin_sensitivity_by_perindopril_in_spontaneously_hypertensive_and_streptozotocin-diabetic_rats

Singh, S., Farswan, M., Ali, S., Afzal, M., Al-Abbasi, F. A., Kazmi, I., & Anwar, F. (2014). Antidiabetic potential of triterpenoid saponin isolated from Primula denticulate. *Pharmaceutical Biology*, *52*(6), 750–755. https://doi.org/10.3109/13880209.2013.869759

Suwardi, A. B., Mardudi, Navia, Z. I., Baihaqi, & Muntaha. (2021). Documentation of medicinal plants used by aneuk jamee tribe in kota bahagia sub-district, south aceh, Indonesia. *Biodiversitas*, *22*(1), 6–15. https://doi.org/10.13057/biodiv/d220102

Taniguchi, A., Fukushima, M., Seino, Y., Sakai, M., Yoshii, S., Nagasaka, S., Yamauchi, I., Okumura, T., Nin, K., Tokuyama, K., Yamadori, N., Ogura, M., Kuroe, A., & Nakai, Y. (2003). Platelet count is independently associated with insulin resistance in non-obese Japanese type 2 diabetic patients. *Metabolism: Clinical and Experimental*, *52*(10), 1246–1249. https://doi.org/10.1016/S0026-0495(03)00099-4

Thieu, V, T., Beth, D, M., Oralee J, V., & Brian, M, F. (2019). Treatment and Prevention of Severe Hypoglycemia in People With Diabetes : Current and New Formulation of Glucagon. *Diabetes Obes Metab*, *2*(9), 469–479. https://doi.org/10.1111/dom.13941

Tiong, S. H., Looi, C. Y., Hazni, H., Arya, A., Paydar, M., Wong, W. F., Cheah, S. C., Mustafa, M. R., & Awang, K. (2013). Antidiabetic and antioxidant properties of alkaloids from Catharanthus roseus (L.) G. Don. *Molecules*, *18*(8), 9770–9784. https://doi.org/10.3390/molecules18089770

Togenu, M., Barisine, F., & Akaninwor, J. O. (2015). Effect Of Aqueous Leaf Extract Of Heinsia Crinata On Haematological And Some Biochemical Indices Of Toxicity In Effect Of Aqueous Leaf Extract Of Heinsia Crinata On Haematological And Some Biochemical Indices Of Toxicity In Streptozotocin Induced Diabetic Rats. *International Journal of Scientific Research and Innovative Technology*, 2(1), 116-126. https://www.semanticscholar.org/paper/EFFECT-OF-AQUEOUS-LEAF-EXTRACT-OF-HEINSIA-CRINATA-Miikue-Yobe-Barisine/8e7a56ba2700a4c7034ca579f26a880763f659c3?utm_source=direct_link

Umamageswari, M. S., Karthikeyan, T. M., & Maniyar, Y. A. (2017). Antidiabetic activity of aqueous extract of Solanum nigrum linn berries in alloxan induced diabetic wistar albino rats. *Journal of Clinical and Diagnostic Research*, *11*(7), 16–19. https://doi.org/10.7860/JCDR/2017/26563.10312

Usman, H., & Osuji, J. C. (2007). Phytochemical And In Vitro Antimicrobial Assay Of The Leaf Extract Of Newbouldia Laevis. *J. Trad. Cam*, *4*(4), 476–480. https://pmc.ncbi.nlm.nih.gov/articles/PMC2816502/

World Health Organization (2018). Global Report on Diabetes. Diabetes Fact Sheet. https://www.who.int/news-room/fact-sheets/detail/diabetes

World Health Organization) (2005). WHO monographs on selected medicinal plants. https://iris.who.int/handle/10665/42052

Willams, W. J., Bentler, E., Erslev, A. J., & Lictman, M. A. (1983). *Thrombocytosis. In: Heamatology, 3rd Edition*. McGraw-Hill.

Xu, J., Wang, S., Feng, T., Chen, Y., & Yang, G. (2018). Hypoglycemic and hypolipidemic effects of total saponins from Stauntonia chinensis in diabetic db/db mice. *Journal of Cellular and Molecular Medicine*, *22*(12), 6026–6038. https://doi.org/10.1111/jcmm.13876

Yamatani, K., Marubashi, S., Wakasugi, K., Saito, K., Sato, N., Takahashai, K., & Sasaki, H. (1994). Catecholamine-Induced cAMP Response in Streptozotocin- Induced Diabetic Rat Liver. *Tohoku J Exp Med*, *173*, 311–320. https://doi.org/10.1620/tjem.173.311

Zafar, M., Naeem-ul-Hassan Naqvi, S., Ahmed, M., & Kaimkhani, Z. A. (2009). Altered Liver Morphology and Enzymes in Streptozotocin Induced Diabetic Rats. *International Journal of Morphology*, *27*(3), 719–725. https://doi.org/10.4067/s0717-95022009000300015

Zhao, J., Najm, A. A., Mahmood, I., Ming, Z. Y., Dutta, P. P., Talib, W. H., Law, D., & Fazry, S. (2025). In Vitro and In Silico Antidiabetic Efficacy of Solanum lasiocarpum Dunal Fruit Extract. *Plos One*, 20(3), 1-19. https://doi.org/10.1371/journal.pone.0312600