**Exploring the Antidiabetic Potential of *Azanza garckeana* Constituents on Streptozotocin-induced Diabetic Rats.**

**ABSTRACT**

Diabetes mellitus is a chronic, incurable metabolic disorder caused by the lack of secretion of insulin by the pancreas. Currently, several plants are used for the treatment of diabetes mellitus. *Azanza garckeana*, a plant with notable medicinal properties, has been characterized by its diverse bioactive metabolites and demonstrated various biological activities, including anti-arthritic, antimicrobial, antidiabetic, wound healing, fecundity-enhancing, and reproductive benefits. This study inves4tigates the antidiabetic effects of methanol extracts from different parts of *Azanza garckeana* in streptozotocin (STZ)-induced diabetic rats. Twenty eight (28) white albino rats weighing about 150–250 g were used for this study and diabetes was induced by intraperitoneal injection of 55 mg/kg body weight of Streptozotocin. The albino rats were randomly divided into seven (7) groups which are as follows: Groups; normal control, diabetic control groups, standard drug (metformin), diabetes treated fruit, diabetes treated leaves, diabetes treated root and diabetes treated stem with *Azanza garckeana* extracts (100 mg/kg) was administered for 28 days. Biochemical parameters, including fasting blood glucose, lipid profile, bilirubin, electrolytes, liver enzymes, and antioxidant enzymes were assessed. The results showed that the crude methanol extract of *Azanza garckeana* significantly reduced blood glucose levels with the leaf (3.06±0.31 b) and fruits (3.77± 0.23b) showed more significant difference when compared to the root (21.81± 0.96 a ) and stem (7.82± 0.40 b) while the protein and albumin biomarkers were significantly (P ≤0.005) increased across groups. It also improved the lipid profiles, restored liver enzyme activity, and enhanced antioxidant defense mechanisms and at the same time a significant positive impact on hematological parameters. These findings support the traditional use of *Azanza garckeana* leaves in diabetes management and suggest its therapeutic potential for metabolic disorders.

*Keywords; Diabetes, Azanza garckeana, Streptozotocin, Phytochemistry*

**INTRODUCTION**

Diabetes mellitus is a chronic metabolic and endocrine disorder characterized by impaired insulin secretion, insulin sensitivity, and carbohydrate, protein, and lipid metabolism. These disruptions lead to hyperglycemia, hyperlipidemia, inflammation, and oxidative stress, which contribute to the onset and progression of diabetes-related complications (Ogunlana et al., 2021; Rangraze et al., 2025).

Diabetes is associated with severe secondary complications, including slow-healing wounds, neuropathy (tingling, pain, or numbness in extremities), cerebrovascular diseases, renal failure, neurological impairments, blindness, and organ dysfunctions, often leading to premature death (mohammadi et al., 2022). The severity of hyperglycemia-induced damage depends on the duration of the disease and the effectiveness of management strategies. Common symptoms include polyuria, blurred vision, polyphagia, polydipsia, and weight loss (Rajavel, 2016).

According to the World Health Organization (WHO) Global Report on Diabetes, over 455 million people currently live with diabetes, with projections indicating an increase to 693 million by 2045 (Nathan, 1993, Roglic, 2016). The three main types of diabetes include: Type 1 diabetes, type II diabetes, and Gestational diabetes. (Diabetes Care, 2018, Murphy et al., 2021).

The literature search showed that several medicinal plants are traditionally used to treat diabetes and its related diseases. Plant-based medicines are safe, active, and widely available. Therefore, more than 80% of people have used traditional medicine to treat various diseases reported by the WHO. The demand for plant-based medicines is increasing tremendously due to their safety and availability (Najmi et al., 2022). Plants produce secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, and ferulic acid, which have proven Antidiabetic properties: Alkaloids are known to inhibit α-glucosidase and reduce glucose transport across the intestinal epithelium, Flavonoids are also known to suppress blood glucose levels and enhance hepatic glucose metabolism by stimulating insulin release from pancreatic islets. Saponins, triterpenoids, and steroidal glycosides, stimulate insulin secretion and inhibit glucose production. Polysaccharides, increase serum insulin levels, improve glucose tolerance, and reduce blood glucose levels. Ferulic acid stimulates insulin secretion (Singh and Patil *et al.,* 2024)

In recent years, natural products have gained attention as potential sources of antidiabetic agents. Azanza garckeana, commonly known as "snop apple" or "Goron Tula," is a fruit-bearing plant native to various African regions (Olayiwola *et al.,* 2021). Traditionally, it has been used in the treatment of chest pain, infertility, menstrual irregularities, cough, sexually transmitted infections, liver diseases, and diabetes (Yusuf *et al.,* 2020; Nkwocha *et al.,* 2024).

A widely accepted method for evaluating potential antidiabetic agents is the Streptozotocin (STZ)-induced diabetic rat model. STZ selectively destroys pancreatic beta cells, causing insulin deficiency and hyperglycemia, thereby mimicking type 2 diabetes pathophysiology. This model serves as a valuable tool for studying the efficacy of natural compounds in diabetes management (Gadewar et al., 2023). This research, aimed to evaluate the antidiabetic potential of methanol leaf, fruit, stem, and root extract of *Azanza garckeana*

**2.0 MATERIALS AND METHODS**

**2.1 Procurement of Materials, Chemicals and Animals**

Twenty eight (28) male albino rats with 150-250 g body weight were purchased from the Animal house in the University of Jos, Nigeria, and ethical clearance was obtained with reference number: F17-00379, the rats were allowed free access to standard pellet feed. All chemicals used in this research work were of reagent grade and purchased from the Sigma Aldrich Company, Germany. Syringes for injections, glucometer to check blood glucose level, and commercial kits to analyze biochemical parameters were purchased from scientific stores and local pharmacies in Jos.

**2.2 Preparation of the Plant Extract**

A fresh sample of the different plant parts of *Azanza garckeana* was collected from Kaltungo Local Government Area of Gombe State in Nigeria. The plant was identified and authenticated at the Forest Herbarium, College of Forestry, Jos, and assigned the voucher specimen number FHJ82022, and deposited for future reference. The different parts of the plant *Azanza garckeana* were washed and dried under the shade. The dried sample was then crushed into powder using a pestle in a laboratory mortar. A closed plastic container was used to store the powdered samples.

The preparation of the plant extract was done through maceration. A total of 1000 g of the different plant parts were soaked in a 70:30 (v/v) mixture of methanol and distilled water in an airtight container for 72 hours, with intermittent stirring. After 72 hours, the mixture was vigorously shaken and filtered using a fine cloth. The filtrate was then concentrated in a water bath at a temperature of 40°C and stored in an air-dried container until required for further analysis. (How and Siow, 2020).

**2.3 Experimental Design**

A total of twenty-eight male white albino rats (Wistar strain), weighing between 150–250 g, were obtained from the Animal House, University of Jos, Plateau State, Nigeria. They were distributed into seven (7) groups of four (4) rats each. Animal handling and experimentation were approved by the Ethical Committee of the University of Jos, Plateau State, Nigeria, in compliance with internationally accepted principles for the humane handling and use of laboratory animals, as outlined in the Canadian Council on Animal Care Guidelines and Protocol Review (Silva, 2021)

**2.4 Induction of Diabetes**

The rats were intraperitoneally administered a freshly prepared solution of streptozotocin (STZ) (55 mg/kg) after overnight fasting. Diabetes was confirmed by a glucose level above 200 mg/kg body weight (Etuk et al., 2023). The rats were then treated with a methanol extract of *Azanza garckeana* parts at 100 mg/kg body weight, while the standard treatment group received metformin (100 mg/kg body weight). All treatments were administered daily for 28 days via the oral route using an esophageal cannula.

**2.5 Sample collections**

Animals in all groups were euthanized under diethyl ether vapour and blood samples were collected by cardiac puncture into clean anticoagulant-free tubes. The blood was allowed to coagulate and then centrifuge at 3000 x g for 15 min, to separate the serum and stored at 4 ◦C to be used for biochemical analysis. (Yazdanbakhsh et al., 2023)

**2.6 Statistical Analysis**

The data collected were presented as Mean ± SEM of 4 replicates and were analyzed using the Duncan multiple range test following one-way Analysis of Variance (ANOVA) using IBM SPSS 23.0 computer software package (SPSS Inc., Chicago U.S.A). Differences at P< 0.05 were considered significant.

**3.0 RESULTS**

The results indicate that the methanol extract of the different parts of *Azanza garckeana* in significantly reduced blood glucose levels while improving total protein, albumin, and lipid profiles in streptozotocin-induced diabetic rats. Liver function markers, including ALT, AST, and ALP, showed improvements after treatment, highlighting hepatoprotective effects of the plant parts. Antioxidant enzyme activity (Catalase, SOD, GSH) increased, while lipid peroxidation (MDA) decreased, suggesting oxidative stress reduction ability. The overall results show the therapeutic potential of *Azanza garckeana* leaves methanol extract

Table 1 Phytochemical properties of Crude Aqueous Extract of *Azanza Garckeana*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Phytochemicals Fruits Leaves Stem bark Root bark | | | | |
| Alkaloids  Flavonoids  Tannins  Terpenes  Steroids  Cardiac glycosides  Anthraquinones  Carbohydrates  Saponins  Phenols | -  +  -  -  +  -  -  +  -  + | +  +  +  +  +  +  -  +  +  + | +  +  -  -  -  -  +  +  +  - | +  +  -  -  -  -  +  +  -  - |

Key: + = Present

= Absent

Table 2: Acute oral Toxicity profiles of *Azanza garckeana*

|  |  |  |  |
| --- | --- | --- | --- |
| Dosage (mg/kg/bw) | Mortality | Physiological observation for sign of adverse effect | Observation after 2 weeks (weight loss, sign of toxicity) |
| 10  100  1000  1600  2900  5000 | 0/4  0/4  0/4  0/4  0/4  0/4 | No observable changes  No observable changes  No observable changes  Nil (MTD)  Restlessness (about 5 minutes)  Hyperactiveness, restlessness, and profuse breathing that lasted for about 30 min. | None  None  None  None  None  None |

BW: body weight, MTD: maximum tolerated dose.

TABLE 3 Effects of Methanol Extracts of *Azanza garckeana* on serum Total Protein, Albumin and Glucose in Streptozotocin induced Diabetic Rats.

|  |  |  |  |
| --- | --- | --- | --- |
| GROUPS | Glucose  (mmol/L) | Albumin  (g/L) | Total Protein  (g/L) |
| Normal Control | 2.82± 0.15 | 43.67 ± 1.50 | 69.82± 5.79 |
| Diabetes Control | 10.84 ± 0.64a | 37.82 ± 1.86a | 57.90 ± 8.85a |
| Diabetic Treated Standard drugs (metformin200 mg/kg) | 6.07± 0.44b | 42.43 ± 1.46 b | 73.95± 1.96b |
| Diabetic Treated Fruit 100 mg/kg | 3.77± 0.23b | 41.10 ± 4.00 b | 70.06 ± 1.16 b |
| Diabetic Treated Leaves 100 mg/kg | 3.06±0.31 b | 41.29 ± 1.64 b | 69.43± 3.50 b |
| Diabetic Treated Root 100 mg/kg | 21.81± 0.96 a | 38.98 ± 1.52a | 75.10 ± 2.30b |
| Diabetic Treated Stem 100 mg/kg  p–values | 7.82± 0.40 b  <0.0001 | 44.44 ± 2.39 b  <0.0001 | 74.41± 2.71 b  <0.0001 |

If p-value is greater than 0.05, mean values are not statistically significant (p < 0.05)

Values are expressed as mean ± SEM (n = 4)

a = statistically significant difference (p < 0.05) compared to normal control

b = statistically significant difference (p < 0.05) compared to diabetic control

TABLE 4 : Effects of Methanol Extracts of *Azanza garckeana* on serum Lipid Profiles in Streptozotocin induced Diabetic Rats.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment Groups | Total  Cholesterol  (mmol/L) | Triglyceride  (mmol/L) | HDL  (mmol/L) | LDL  (mmol/L) |
| Normal control | 3.95 ± 0.05 | 0.93 ± 0.03 | 1.30 ± 0.05 | 1.92 ± 0.13 |
| Diabetic control | 5.97 ± 0.05a | 2.87 ± 0.43a | 0.47 ± 0.01a | 3.33 ± 0.03a |
| Diabetic Treated Standard drugs (metformin 200mg/kg) | 4.80 ± 0.20b | 1.16 ± 0.05 b | 1.09 ± 0.03 b | 2.05 ± 0.04 b |
| Diabetic Treated Fruit 100 mg/kg | 4.73 ± 0.86 b | 1.49 ± 0.14 b | 0.57 ± 0.07 b | 2.08 ± 0.40 b |
| Diabetic Treated Leaves 100 mg/kg | 3.99 ± 0.08 b | 0.98 ± 0.09 b | 1.27 ± 0.09 b | 1.96 ± 0.04 b |
| Diabetic Treated Root100 mg/kg | 5.00 ± 0.69 b | 2.51 ± 4.71ab | 0.80 ± 0.01 b | 2.01 ± 0.01 b |
| Diabetic Treated Stem 100 mg/kg  p-values | 4.72 ± 0.27 b  <0.0001 | 1.97 ± 0.79 b  <0.0001 | 1.07 ± 0.03 b  <0.0001 | 1.83 ± 0.04 b  <0.0001 |

If p-value is greater than 0.05, mean values are not statistically significant (p < 0.05)

Values are expressed as mean ± SEM (n = 4)

a = statistically significant difference (p < 0.05) compared to normal control

b = statistically significant difference (p < 0.05) compared to diabetic control

TABLE 5 : Effects of Methanol Extracts of *Azanza garckeana* on some Enzymes in Streptozotocin induced Diabetic Rats

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment Groups | AST (U/L) | ALT (U/L) | ALP (U/L) |
| Normal Control | 70.18 ± 1.12 | 23.00 ± 0.82 | 65.60 ± 3.96 |
| Diabetic Control | 114.87 ± 4.27a | 30.24 ± 1.89a | 86.94 ± 1.06a |
| Diabetic Treated Standard Drug (metformin) | 82.51 ± 11.72 b | 23.24 ± 16.34 b | 68.34 ± 2.55 b |
| Diabetic Treated Fruit 100 mg/kg | 73.70 ± 2.12 b | 23.50 ± 1.29 b | 63.00 ± 2.75 b |
| Diabetic Treated Leaves 100 mg/kg | 72.27 ± 1.88 b | 20.11 ± 1.92 b | 64.46 ± 1.56 b |
| Diabetic Treated Root 100 mg/kg  Diabetic Treated | 97.31 ± 0.92a b | 30.75 ± 0.50a | 94.11 ± 0.85a |
| Stem 100 mg/kg  p-values | 80.97 ±15.04 b  <0.0001 | 24.00 ±3.37 b  <0.0001 | 64.34 ± 11.18 b  <0.0001 |

If p-value is greater than 0.05, mean values are not statistically significant (p < 0.05)

Values are expressed as mean ± SEM (n = 4)

a = statistically significant difference (p < 0.05) compared to normal control

b = statistically significant difference (p < 0.05) compared to diabetic control

TABLE 6: Effects of Methanol Extracts of *Azanza garckeana* on some Antioxidant Enzymes in Streptozotocin induced Diabetic Rats

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment Groups | LPO/MDA  (nm/mg) | GSH  (μg/mg) | SOD  (%) | CATALASE  (umo/mg) |
| Normal control | 0.59 ± 0.06 | 13.88 ± 0.32 | 33.74 ± 1.23 | 10.38 ± 0.71 |
| Diabetic control | 1.35 ± 0.32a | 4.75 ± 1.26a | 22.35 ± 4.29a | 5.29 ± 1.09a |
| Diabetic Treated standard drug (metformin 200 mg/kg) | 0.49 ± 0.54b | 9.69 ± 1.71b | 19.76 ± 1.89a | 8.42 ± 1.21ab |
| Diabetic Treated Fruit 100 mg/kg | 0.53 ± 0.84b | 9.09 ± 1.76b | 29.16 ± 4.03b | 8.17 ± 2.48ab |
| Diabetic Treated Leaves 100 mg/kg | 0.69 ± 0.12b | 9.38 ± 144b | 31.13 ± 9.32b | 10.38 ± 1.85b |
| Diabetic Treated Root 100 mg/kg | 0.74 ± 0.16b | 11.28 ±1.01b | 31.12± 5.30b | 10.91 ± 0.72b |
| Diabetic Treated Stem 100 mg/kg  p-values | 0.69 ± 0.06b  <0.0001 | 9.08 ± 0.52b  <0.0001 | 20.27 ± 3.22a  <0.0001 | 7.74 ± 2.54ab  <0.0001 |

If p-value is greater than 0.05, mean values are not statistically significant (p < 0.05)

Values are expressed as mean ± SEM (n = 4)

a = statistically significant difference (p < 0.05) compared to normal control

b = statistically significant difference (p < 0.05) compared to diabetic control

TABLE 7 : Effects of Methanol Extracts of *Azanza garckeana* on serum Total bilirubin and direct bilirubin in Streptozotocin induced Diabetic Rats.

|  |  |  |
| --- | --- | --- |
| Treatment Groups | Total Bilirubin (umol/L) | Direct Bilirubin (umol/L) |
| Normal Control | 8.41 ± 0.34 | 4.64 ± 0. 06 |
| Diabetic control | 28.67 ± 0.27a | 11.14 ± 0.18a |
| Diabetic Treated Standard drugs (metformin 200 mg/kg) | 16.14 ± 0.09 b | 5.95 ± 0.19 b |
| Diabetic Treated Fruit 100 mg/kg | 17.15 ± 0.09 b | 8.71 ± 0.24 b |
| Diabetic Treated Leaves 100 mg/kg | 9.14 ± 0.20 b | 4.61 ± 0.05 b |
| Diabetic Treated Root 100 mg/kg | 22.01 ± 0.06a b | 9.04 ± 0.02a b |
| Diabetic Treated Stem 100 mg/kg  p- values | 19.10 ± 0.19 b  <0.0001 | 8.03 ± 0.07 b  <0.0001 |

If p-value is greater than 0.05, mean values are not statistically significant (p < 0.05)

Values are expressed as mean ± SEM (n = 4)

a = statistically significant difference (p < 0.05) compared to normal control

b = statistically significant difference (p < 0.05) compared to diabetic control

TABLE 8: Effects of Methanol Extracts of *Azanza garckeana* on Serum Electrolytes in Streptozotocin-induced Diabetic Rats.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment Groups | Sodium  (mmol/L) | Potassium  (mmol/L) | Chloride  (mmol/L) | Bicarbonate  (mmol/L) |
| Normal Control | 139.79 ± 2.68 | 3.19 ± 0.39 | 72.11 ± 1.46 | 22.50 ± 0.58 |
| Diabetic Control | 148.19 ± 3.25a | 2.83 ± 0.49a | 79.29 ± 10.63a | 17.25 ± 0.58a |
| Diabetic Treated Standard drug (200 mg/kg) | 144.48 ± 3.25b | 3.74 ± 0.10 b | 78.24 ± 9.83 b | 22.75 ± 0.96 b |
| Diabetic Treated Fruit 100 mg/kg | 138.43 ± 0.22b | 3.05 ± 0.29b | 80.21 ± 2.29ab | 22.00 ± 0.82 b |
| Diabetic Treated Leaves 100 mg/kg | 132.43 ± 0.77 b | 3.74 ± 0.10b | 71.76 ± 1.76 b | 22.00 ± 0.82b |
| Diabetic Treated Root 100 mg/kg | 138.98 ± 0.96 b | 3.57 ± 0.29 b | 82.04 ± 1.45ab | 23.25 ± 0.50b |
| Diabetic Treated Stem 100 mg/kg  p-values | 140.87 ± 1.57b  <0.0001 | 2.98 ± 0.13b  <0.0001 | 85.44 ± 0.13ab  <0.0001 | 23.25 ± 0.96 b  <0.0001 |

If p-value is greater than 0.05, mean values are not statistically significant (p < 0.05)

Values are expressed as mean ± SEM (n = 4)

a = statistically significant difference (p < 0.05) compared to normal control

b = statistically significant difference (p < 0.05) compared to diabetic control

TABLE 9 : Effects of Methanol Extracts of *Azanza garckeana* on Urea, Uric acid, and Creatinine in Streptozotocin induced Diabetic Rats.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatment Groups | | Urea Uric  acid | | Creatinine | |
|  | (mmol/L) | | (umol/L) | | (mmol/L) |
| Normal Control | 4.01 ± 0.40 | | 353.16 ± 33.07 | | 50.647 ± 0.80 |
| Diabetic Control | 5.71 ± 0.82a | | 937.13 ± 55..60a | | 56.67 ± 5.89a |
| Diabetic Treated Standard drug (metformin 200 mg/kg) | 5.38 ± 0.50 b | | 438.23 ± 41.47 b | | 48.43 ± 1.41b |
| Diabetic Treated Fruit 100 mg/kg | 6.51 ± 0.62a b | | 516.09 ±14.09 b | | 49.32 ± 3.34b |
| Diabetic Treated Leaves 100 mg/kg | 4.66 ± 0.35a | | 360. 36 ± 15.36 b | | 49.55 ± 1.94b |
| Diabetic Treated Root 100 mg/kg | 5.98 ± 0.65ab | | 670.59 ± 76.01ab | | 62.82 ± 0.86a |
| Diabetic Treated Stem 100 mg/kg  p-values | 5.84 ± 0.81b  <0.0001 | | 331.79 ± 16.70 b  <0.0001 | | 47.26 ± 1.85b  <0.0001 |

NC = Normal Control, DC = Diabetic Control, Values are expressed as mean ± SEM, n=4.

Post hoc analysis was done using Tukey- Kramer Multiple Comparisons Test

If p-value is greater than 0.05, there is significant difference in mean values

aValue are statistically significant when compared to normal control (p < 0.05)

bValue are statistically significant when compared to diabetic control (p < 0.05)

**4.0 DISCUSSION**

Diabetes is a common pancreas disorder that affects at least 100 million people globally. This number is expected to double by the year 2030. In most of the lowest-income countries, including Nigeria, there has been a disturbing upsurge in the number of diabetics over the past decade. Several pharmaceutical drugs, such as thiazolidinediones, biguanides, and insulin, are used in modern medicine to control blood glucose. These drugs have hypoglycemic activities but can produce several health problems, such as neural disorders, diarrhea, heart diseases, and many others. (Akhtar *et al.,* 2024)

Our findings reveal that diabetes-induced in rats by streptozotocin resulted in a significant (*p* < 0.05) increase in serum glucose levels, which could be caused by the selective destruction of pancreatic β-cells through the production of nitric oxide (NO) (Arain et *al.,* 2025; Chen *et al.,* 2022). Following treatment with 100 mg/kg methanol extracts from different parts of the plant, the elevated glucose levels in diabetic rat’s significantly decreased (*p* < 0.05) compared to the diabetic control group. Among the extracts tested, the methanol leaf extract was the most effective in lowering glucose levels. Decrease in serum protein levels in diabetic rats, which might indicate a distortion in protein metabolism. According to (Gobinath *et al.,*2022), insulin deficiency leads to increased protein catabolism to provide amino acids for gluconeogenesis, resulting in muscle wasting and weight loss in diabetic control rats. However, after treatment with different parts of *Azanza garckeana*, a significant (*p* < 0.05) increase in serum total protein levels was observed in the diabetic group treated with 100 mg/kg of leaf methanol extract

Hypoalbuminemia, or low albumin levels, is a common complication in diabetic animals and is generally attributed to the presence of diabetic nephropathy (Rajora and Nagpal, 2021). The reduced serum albumin levels observed in diabetic rats increased following the administration of 100 mg/kg of crude methanol extracts of *Azanza garckeana*, suggesting that the plant extract supports albumin synthesis and liver function.

The increase in serum lipid profile (TC and TG) and lipoprotein fraction (LDL cholesterol), along with a decrease in HDL cholesterol in streptozotocin-induced diabetic rats, aligns with other studies that observed similar alterations in lipid profiles under diabetic conditions (Rossol *et al., 2023*; Murugan, (2021). The increase in HDL-C levels after treatment is particularly important, as HDL-C plays a crucial role in transporting cholesterol from peripheral cells to the liver via a process known as reverse cholesterol transport, which is considered a cardioprotective mechanism. (Akindele *et al.,* 2015, Nandini and Naik, 2019).

AST and ALT serve as key indicators of liver function, and their release is associated with liver injury, particularly mitochondrial damage in hepatic cells (Denkok *et al.,* 2021). Elevated levels of these enzymes indicate cellular damage, leakage, and compromised functional integrity of the hepatic cell membrane (Omonije *et al.,* 2019). The increased enzyme levels observed in diabetic rats may also be attributed to the hepatotoxic effects of streptozotocin. However, treatment with crude methanol of *Azanza garckeana* at 100 mg/kg significantly (p < 0.05) reduced liver enzyme levels.

Administration of *Azanza garckeana* extract significantly increased the activities of SOD, CAT, and GSH, indicating its protective effects. This suggests that the extract may reduce reactive oxygen species and improve the activities of antioxidant enzymes associated with diabetes by inhibiting lipid peroxidation. The protective effects of methanol leaf extract of *Azanza garckeana* may be due to either the direct scavenging of reactive oxygen species, attributed to the presence of various antioxidant compounds, or the stimulation of antioxidant molecule synthesis (Felemban *et al.,* 2024). These results are consistent with other studies on green tea supplementation in diabetic rats and hepatic dysfunction, which demonstrated an increase in antioxidant enzyme levels. The observed antioxidant effects may be linked to flavonoids and phenols present in *Azanza garckeana*, which possess free radical scavenging properties (Yusuf *et al.,* 2023; Lawal *et al.,* 2022).

.**CONCLUSION**

The methanol extracts of *Azanza garckeana* demonstrated antidiabetic, hepatoprotective, and anti-inflammatory properties, with the leaves extract being the most potent. These findings support the traditional use of *Azanza garckeana* in managing diabetes and related complications.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The experimental design was conducted by the guidelines approved by the Institutional Animal Ethics Committee of the University of Jos, Nigeria.

**REFERENCES**

.

ADA (2022). Standards of medical care in diabetes. Diabetes Care, 45(Suppl. 1), S1–

Akindele, A. J., Otuguor, E., Singh, D., Ota, D., & Benebo, A. S. (2015). Hypoglycemic, antilipidemic, and antioxidant effects of valproic acid in alloxan-induced diabetic rats. European Journal of Pharmacology, 762, 174–183. <https://doi.org/10.1016/j.ejphar.2015.05.044>

Akhtar, N., Virk, S. T., Zubair, A., & Mehboob, S. (2024). Precision Medicine Approaches in Diabetes Management: Targeting Individualized Pathways. *Innovative Research in Applied, Biological and Chemical Sciences*, *2*(1), 5-12.

Arain, M. A., Khaskheli, G. B., Barham, G. S., Shah, Q. A., Nabi, F., Almutairi, M. H., ... & Marghazani, I. B. (2025). Exploring the anti-diabetic properties of camel milk: effects on blood glucose, antioxidant defense, and organ histo-morphological features in rabbits. *Journal of Molecular Histology*, *56*(2), 92.

Aruoma, O.I., Free Radicals and Foods, Chem. Br. 29:210–214 (1993).

Chen, H. Y., Hong, Y. H., Chiang, Y. F., Wang, K. L., Huang, T. C., Ali, M., ... & Hsia, S. M. (2022). Effects of rice-husk silica liquid in streptozotocin-induced diabetic mice. *Metabolites*, *12*(10), 964.

Denkok, Y., Linus, V. G., Oyebade, K. F., Ukeme, A. S., Gazuwa, S. Y., & Longdet, I. Y. An Investigation on Some Hepatic Enzymes and Haematological Variables among Alcoholic Volunteers in Kadima District of Jos South Local Government Area of Plateau State, Nigeria.

Dikko, Y., Khan, M., Tor-Anyiin, T., Anyam, J., & Linus, U. (2016). In vitro antimicrobial activity of fruit pulp extracts of Azanza garckeana (F. Hoffm.) Exell & Hillc. and isolation of one of its active principles, betulinic acid. Journal of Pharmaceutical Research International, 1-10.

Etuk, I. C., Udobang, J. A., Ebong, N. O., & Okokon, J. E. (2023). Solanum anomalum leaf extract and fractions attenuate oxidative stress and liver injuries in alloxan- induced diabetic rats. *Biology, Medicine, & Natural Product Chemistry*, *12*(1), 33- 44.

Felemban, S. A., Alhulaysi, M. D. A. A., Sait, H. B., Alhnnaishi, R. A., Alharbi, A. S., Allihaibi, F. M., ... & Alotaibi, S. F. (2024). Wound healing is aided by glutathione peroxidase, a selenoprotein. *Journal of International Crisis and Risk Communication Research*, *7*(S7), 401.

Gadewar, M., et al. (2023). STZ-induced diabetes model. Journal of Pharmacological Research, 34(2), 120-130.

Gupta, R. et al. (2012). Flavonoids as potential therapeutic agents for diabetes. Phytotherapy Research, 26(1), 1-14.

Harborne, J.B. (1998). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman & Hall.

How, Y. K., & Siow, L. F. (2020). Effects of convection-, vacuum-and freeze-drying on antioxidant, physicochemical properties, functional properties and storage stability of stink bean (Parkia speciosa) powder. *Journal of Food Science and Technology*, *57*(12), 4637-4648.

Kumar, R., Singh, J., & Mehta, A. (2021). Flavonoids as potential anti-inflammatory agents. Journal of Natural Products Research, 35(3), 129-145.

Md Sohail Akhtar1 Mohamed Rafiullah · Mohammad Amzad Hossain · Mohammed Ali (2023) Antidiabetic activity of Cichorium intybus L water extract against streptozotocin induced diabetic rats

Mohammadi, A. T., Karami, S., Jahandideh, A., Sarejloo, S., Vaseghi, S., Rezaei, M. D., ... & Gholami, S. (2022). *Human diseases Research and textbook 1: Heart, Diabetes, Bacterial, ADHD, skin*. Nobel TM.

Murphy, H. R., Howgate, C., O'Keefe, J., Myers, J., Morgan, M., Coleman, M. A., ... & Tomkins, N. (2021). Characteristics and outcomes of pregnant women with type 1 or type 2 diabetes: a 5-year national population-based cohort study. *The lancet Diabetes & endocrinology*, *9*(3), 153-164.

Murugan, P. (2021). Effect of tetrahydrocurcumin on lipid profiles in streptozotocin- nicotinamide induced type 2 diabetes mellitus.

Nabi, S. et al. (2013). STZ-induced β-cell damage and diabetes. Diabetes & Metabolism Journal, 37(3), 200-210.

Nandini, H. S., & Naik, P. R. (2019). Antidiabetic, antihyperlipidemic, and antioxidant effect of vincamine in streptozotocin-induced diabetic rats. European Journal of Pharmacology, 843, 233–239. https://doi.org/10.1016/j.ejphar.2018.11.034

Nathan, D. M. (1993). Long-term complications of diabetes mellitus.

Najmi, A., Javed, S. A., Al Bratty, M., & Alhazmi, H. A. (2022). Modern approaches in the discovery and development of plant-based natural products and their analogues as potential therapeutic agents. *Molecules*, *27*(2), 349.

Nkwocha, C. C., Felix, J. O., Michael, L. O., & Ale, B. A. (2024). Phytochemical screening and GC-FID identification of bioactive compounds in n-hexane, ethylacetate and methanol fractions of methanolic leaves extract of Azanza garckeana. *Food Chemistry Advances*, *4*, 100712.

Ogunlana, O. O., Fakoya, A., & Adepoju, G. (2021). Role of oxidative stress in diabetes mellitus. Journal of Biomedical Sciences, 20(4), 56-65.

Ojo, O. A., Okesola, M. A., Ekakitie, L. I., Ajiboye, B. O., Oyinloye, B. E., Agboinghale, P. E., & Onikanni, A. S. (2020). Gongronema latifolium Benth. Leaf extract attenuates diabetes‐ induced neuropathy via inhibition of cognitive, oxidative stress and inflammatory response. Journal of the Science of Food and Agriculture, 100(12), 4504-4511.

Olayiwola, V. A., Abiodun, F. O., Ojedokun, R. O., Kolawole, I. O., & Ihediuche, C. I. (2021). Early Growth Response of Azanza garckeana (Exell & Hillc) as Influenced by Organic and Inorganic Fertilizers. *Nigeria Agricultural Journal*, *52*(2), 284-288.

Rangraze, I. R., El-Tanani, M., Rabbani, S. A., Babiker, R., Matalka, I. I., & Rizzo, M. (2025). Diabetes and its Silent Partner: A Critical Review of Hyperinsulinemia and its Complications. *Current Diabetes Reviews*, *21*(9), e15733998311738.

Reitman, S., & Frankel, S. (1957). A colorimetric method for the determination of serum transaminases. American Journal of Clinical Pathology, 28(1), 56-63.

Rajavel, V. (2016). *Dose-And Time Dependent Effects of Oil-Palm (Elaeis Guineensis) Leaf Extract in Streptozocin-Induced Oxidative Stress and Renal Damage in Diabetic Rats* (Doctoral dissertation, University of Malaya (Malaysia)).

Roglic, G. (Ed.). (2016). *Global report on diabetes*. World Health Organization.

Rajora, A., & Nagpal, K. (2021). Nanotechnology Mediated Diagnosis of Type II Diabetes Mellitus. *Recent Innovations in Chemical Engineering (Formerly Recent Patents on Chemical Engineering)*, *14*(4), 272-298.

Steel, R.G.D., & Torrie, J.H. (1980). Principles and Procedures of Statistics. McGraw- Hill.

Silva Sobrinho, F. B. D. (2021). Análise mecânica comparativa de diferentes métodos de estabilização de osteotomia do olécrano de cão utilizando corpos de prova impressos 3D.

Singh, S. S., & Patil, K. N. (2024). SIRT1/AMPK-mediated pathway: Ferulic acid from sugar beet pulp mitigating obesity-induced diabetes-linked complications and improving metabolic health. *Biochimica et Biophysica Acta (BBA)-Molecular and Cell Biology of Lipids*, *1869*(7), 159511.

Sudhakaran, G., Rajesh, R., Guru, A., Haridevamuthu, B., Murugan, R., Bhuvanesh, N., ... & Arockiaraj, J. (2022). Deacetylated nimbin analog N2 fortifies alloxan- induced pancreatic β-cell damage in insulin-resistant zebrafish larvae by upregulating phosphoenolpyruvate carboxykinase (PEPCK) and insulin levels. *Toxicology and Applied Pharmacology*, *454*, 116229.

Yazdanbakhsh, M., Deyhim, M. R., Jafary, H., Rafiee, M. H., & Moradi, M. (2023). Biochemical analytes in centrifuged blood samples could be affected by the age of subjects in different time periods and storage temperatures. *Asian Journal of Transfusion Science*.

Yusuf, M. et al. (2020). Ethnopharmacology of Azanza garckeana. Journal of Herbal Medicine, 24, 100385.