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COMPARATIVE ANTI-DIABETIC ACTIVITIES OF *Lawsonia inermis, Crysophyllum albidum, Allium sativum, And Mangifera indica* USED IN AFRICAN TRADITIONAL SETTINGS

***[1]Abdulfatai Aremu, [1]Boluwatife Ipeminogenah Ajakaiye, [1]Ganiu Jimoh Akorede , [1]Aishat Omobolanle Olatunji , [2]Yusuf Kolawole Suleiman, [3]Akeem Olayiwola Ahmed**

[1]Department of Veterinary Pharmacology and Toxicology; Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria.
[2]Department of Veterinary Physiology and Biochemistry ; Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria.
[3]Department of Veterinary Microbiology, Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria.

*Corresponding authors' email: aremu.a@unilorin.edu.ng

ABSTRACT

Diabetes mellitus is one of the major endocrine illnesses affecting over 100 million individuals worldwide. medicinal plants have been used for the treatment of diabetes with little incidence of toxicity. Aim is to compare the anti-diabetic activities of *Lawsonia inermis, Chrysophyllum albidum, Allium sativum* and *Mangifera indica* in Streptozotocin induced diabetic rats. Acute toxicity study was conducted using adult female Wistar rats (n=36). The comparative anti-diabetic study involved the use of male rats (n=35) grouped into (1-7) of five rats per groups. Group 1 (Negative control), 2 (Positive control), 3 (*Lawsonia inermis* at 200 mg/kg), 4 (Chrysophyllum albidum at 200 mg/kg), 5 (Allium sativum at 200 mg/kg), 6 (*Mangifera Indica* at 200 mg/kg), and 7 (Metformin at 500 mg/kg). Methanolic extract of L. inermis C. albidum, A. sativum and M. indica were not toxic at ≤5000 mg/kg. All the extracts exhibited anti-diabetic activities by significantly reducing the blood glucose in the order of L. inermis, A. sativum, C. albidum, and M. Indica. PCV decreased significantly in C. albidum, and M. indica. RBC increased significantly in L. inermis treated group while it reduced significantly in C. albidum and M. indica. Hb concentration followed similar trends increasing significantly in C. albidum, and M. indica. Lawsonia inermis possess significant anti-diabetic activities with significant modulatory effect on haematology and biochemistry when compared to other plants.

Keywords: Allium sativum, Chrysophyllum albidum, Diabetes, Lawsonia inermis, Mangifera indica, Metformin, Wistar rats

INTRODUCTION

Diabetes mellitus usually a complicated and varied group of metabolic disorders that impacts how fat, protein, and glucose are metabolised (Poznyak *et al.,* 2020). Hyperglycaemia is brought on by either decreased tissue sensitivity to insulin or insufficient insulin synthesis. (Papachristoforou, *et al.,* 2020). The disease was reported to affect 366 million people in 2011 rising to 552 million by 2030 (Patil *et al.,* 2023). It has become more widespread worldwide as a result of global industrialization and the startling increase in obesity (Mohajan *et al.,* 2023). In 2026, China, India, and the United States will be the leading nations that will be most impacted by diabetes pandemic (Goyal *et al.,* 2020). Diabetes is of utmost important priority in Africa but the scant statistics on it can be attributed to the lack of research on the financial cost of the disease. Africa experienced the largest increase in the global burden of diabetes and its associated consequences, contributing the to the least annual global healthcare costs linked to treatment of diabetes (Liu *et al.,* 2020). According to reported estimates from the International Diabetes Federation (IDF), almost two thirds of Africans have undiagnosed diabetes mellitus (Dessie *et al,* 2020). In Nigeria, report have shown that diabetes mellitus claimed over 40,000 lives and this significant loss is attributable to the absence of adequate and efficient healthcare delivery (Balogun, 2022). Recent meta-analysis report showed that; about 6 million adult Nigerian are estimated to have diabetes mellitus and this figure represents a very small percentage of the two-thirds of diabetes cases in Nigeria that are believed to be untreated (Esan *et al.,* 2024).

Traditional Medicines (TMs) have an important application in the history of medical practices through its usage in the treatment of both infectious and non-infectious diseases (Aladejana *et al.,* 2024). In many regions of the world, natural medicine has been practiced for hundreds or even thousands of years (Izah *et al.,* 2024). These methods include; Unani, Kampo, Traditional Korean medicine (TKM), Ayurveda, African Traditional Medicine (ATM) and Traditional Chinese Medicine (TCM). These processes and practices have today grown into organized and regulated medical systems (Ansari, 2021). Medicinal plants have been used both independently and in combination with other drugs and (Aremu *et al.,* 2022) conventional plant medicine is the source of most commonly prescribed drugs (Skalli *et al.,* 2017).

The medicinal uses of *Lawsonia inermis, Crysophyllum albidum, Allium sativum, and Mangifera indica* demonstrate the rich diversity of therapeutic compounds present in plants that have been employed for centuries to promote health and treat disease (Ullah *et al.,* 2020). Medicinal activities of these plants range from the antimicrobial and anti-inflammatory properties of *L. inermis* and *C. albidum* to the cardiovascular and anticancer benefits of *A. Sativum* and *M. indica*, these plants exemplify the profound impact that traditional plant-based medicine can have on human health (Smith, 2019). Modern scientific research continues to uncover the mechanisms behind these healing properties, further validating the wisdom embedded in traditional healing practices (Pereira *et al.,* 2017). Various reports have shown that these plants possess a significant anti-diabetic activity and this study was conducted to compare the anti diabetic activities of four medicinal plants; *Lawsonia inermis*, *Chrysophyllum albidum*, *Allium sativum*, and *Mangifera indica* used in African setting compared with a standard drug (Metformin).

MATERIALS AND METHODS

Ethical Approval

This work was ethically approved by Unilorin ethical committee who is the regulatory body in charge of animal use at University of Ilorin (Nigeria). Full approval with the assigned number: **UERC/FVM/2024/025** dated 30/07/2024

Plant Collection, Identification and Preparation

Leaves of *Lawsonia inermis*, *Chrysophyllum albidum*, *Allium sativum* and *Mangifera indica* and were collected from different region across Nigeria. Taxonomically, they were identified and authenticated at the University of Ilorin Herbarium and samples were deposited.

Extraction and Separation

2 kg each of *Lawsonia inermis*, *Chrysophyllum albidum, Allium sativum* and *Mangifera indica* were macerated in methanol separately for 72 hours. The mixtures were then decanted. The filtrates of each plant were evaporated at temp 40°C. The concentrate (wet residue from different plants) was dried and stored at 4°C.

Experimental Animal and Ethical Consideration

13 weeks old male Wistar rats (130-150 g) were obtained and housed at the experimental Animal House, Department of Veterinary Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Ilorin. Ethical approval was obtained from the University of Ilorin Ethical review committee and ethical approval with number **UERC/FVM/2024/025** was assigned.

Acute Toxicity Study

A toxicity study of crude methanol extract of *Lawsonia inermis*, *Allium sativum, Chrysophyllum albidum* and *Mangifera indica* was carried out following the method of Organisation for Economic Co-operation and Development (OECD) guideline 425. Twelve female rats were grouped into four for each of the extract (n=35). The first group was treated with distilled water and served as control while the remaining three groups were administered with crude methanolic extract of *Lawsonia inermis* Linn. leave at 1000, 2000 and 5000 mg/kg body weight respectively.

Anti-diabetic Study

Male Wistar rats between 130-150 g, (n=35) were used. Experimental rats were housed in standard rat cage and maintained at ideal conditions under appropriate temperatures and humidity. The rats were fed with Chicum(R) feed (standard animal feed). Feed and water were provided *ad libitum*. The blood glucose of all the experimental rats was assessed using a fine test glucometer (United Kingdom) prior to the start of the experiments.

Diabetes Induction

Experimental diabetes was induced using Streptozotocin (STZ) (sigma®). STZ was dissolved with injection water and intraperitoneally dosed at 65 mg/kg.

Table 1: Animal Grouping

Animal Grouping	
Group 1	(Negative control) uninduced and untreated but given distilled water.
Group 2	(Positive control) induced and untreated but given distilled water.
Group 3	*Lawsonia inermis* extract administered orally at 200 mg/kg daily for 21 days
Group 4	*Chrysophyllum albidum* was administered orally at 200 mg/kg daily for 21 days.
Group 5	*Allium sativum* extract administered orally at 200 mg/kg daily for 21 days.
Group 6	*Mangifera indica* extract administered orally at 200 mg/kg daily for 21 days.
Group 7	Metformin administered orally at 500 mg/kg daily for 21 days

Constitution and Administration of the Extracts

The stock concentration of the four extracts was prepared by mixing 2 mL of distil water with 0.5 g of the extract to dissolve it. These preparations were administered orally at 200 mg/kg as shown above to the diabetic rats for 21 days. The control groups were treated using distilled water.

Weight Estimation

The weights of all the experimental animals in all groups were monitored from day 1. The initial weight was recorded and thereafter weighed weekly using an automated electronic scale (Satorious group Switzerland). A round metal container was placed on the scale and tarred to zero.

Monitoring of Blood Glucose Level (BGL)

The blood glucose level was monitored in the experimental test groups on Day 0 (24 hours), Day 1, 7, 14 and 21 using the conventional fine test glucometer and strips.

Blood Sample Collection and Animal Sacrifice

Two to three millilitres of blood sample were collected using heparin and plain sample bottles. The entire rats in all the groups were sacrificed humanely using chloroform as light anaesthesia. To achieve this, a small quantity of chloroform was placed on cotton wool. The rat was placed in a small air-tight plastic container and the ether-soaked cotton wool was placed on the nostril of the rat and subsequently covered. The anaesthetized rats were humanly killed after five minutes. The organs such as the liver, brain, kidney, pancreas, eyes, heart and testes were harvested for oxidative stress markers, inflammatory biomarkers and histopathology.

Haematological Analysis

Haematological parameters evaluated were PCV RBC, HB and WBC and differential white cell counts using a fully automatic blood counter (Ehmma® PCE 210). The values for all the Red Blood cell indices were calculated.

Biochemical Analysis

The serum biochemicals were determined using commercial test kits (Randox® Netherlands) and this includes ALT, ASP, ALP, urea and creatinine using various kits, Randox® Chemicals Netherlands.

Statistical Analysis

Generated data were recorded as Mean ±SD of all the measured values. All were data analysed using ANOVA and were subjected to further tests using Dunnet's Post-Hoc multiple comparison test. GraphPad Prism software statistical package, version 5.03 (San Diego, U.S.A) was used for all

analyses. The p-value of p≤0.05 were considered as significant values

RESULTS AND DISCUSSION

Acute toxicity of *Lawsonia inermis*, *Chrysophyllum albidum*, *Allium sativum* and *Mangifera indica*

No signs of toxicity were observed in rats treated with the three (dosages) of the extracts (*Lawsonia inermis*, *Chrysophyllum albidum*, *Allium sativum* and *Mangifera indica*) at 1000, 2000 and 5000 mg/kg. No signs of systemic toxicity and no mortality in all the treated rats. Thus, following Lorke's method (1983), the LD_{50} of these extracts were above 5000 mg/kg and the extracts were considered to be relatively safe.

Percentage Weight Gain

The percentage weight gain of treated diabetic rats showed that *M. Indica, A sativum* and *C. albidum* was at 4.4%, 4.3%, 4.2% respectively while metformin increased by 6.7.% when compared to untreated non-diabetic control with 10.3% weight gain. *L. inermis* had the least weight gain at 3.2% compared to untreated diabetic control that reduced significantly at -13.3% (Table 2).

Table 2: Percentage Weight Changes over 21-days following Treatment of STZ-induced Diabetic Wistar Rats using Acute Toxicity of *Lawsonia inermis*, *Chrysophyllum albidum*, *Allium sativum* and *Mangifera indica*

DYs	NC	PC	LI	CA	AS	MI	MF
1	164.6±31.52	167.8±24.24	194.2±23.70	190.8±32.5	182.6 ± 17.07	248.8 ± 43.56	223.0± 48.38
7	167.0 ±33.47	161.5±27.69	196.0±44.93	195.7±2.06	183.7 ± 14.15	244.3± 38.57	206.2± 48.71
14	172.4±32.53	158.5±9.19	197.3±17.62	198.0± 5.29	183.3± 15.95	247.5±47.22	207.5±43.49
21	176.5±25.72	145.5±7.78	201.3±16.29	198.7±4.16	190.3±12.86	259.0±51.51	238.0± 41.98
%wg	**(10.3%)**	**(-13.2%)**	**(3.7%)**	**(4.2%)**	**(4.3%)**	**(4.4%)**	**(6.7%)**

All values are expressed in Mean ± SD (standard deviation of mean)
Significantly higher (P≤0.05)

Blood Glucose Level (BGL)

The BGL results showed a significant increased values across the 21 days in untreated diabetic rats when compared to the treatment groups. There was no significant increase BGL in the diabetic treated groups when compared to the normoglycaemic control (NC) (Table 3).

Table 3: Comparative Anti-Diabetic Activities of the extracts Four Medicinal Plants on the Blood Glucose Level (BGL) of Treated Diabetic Rats

Days	NC	PC	LI	CA	AS	MI	MF
1	114.4±30.14	307.4±115.7*	216.0±15.6	455.0±33.6*	321.4±120.5*	269.4±81.01	223.0 ±47.43
7	90.20 ±11.43	327.5±120.2*	156.0 ± 45.74	378.3±186.3*	183.7±14.15	150.3±88.17	153.8±118.3
14	120.2 ±32.39	329.5±41.72*	123.3± 32.52	135.0± 48.57	183.3± 15.95	131.5±73.88	149.75±28.34
21	89.75±11.44	344.0±48.08*	83.67 ± 9.29	93.33 ± 14.43	92.00±7.00	116.3±46.69	97.75± 22.25

All values are expressed in Mean ± SD (standard deviation of mean)
Significantly higher (P≤0.05)

Comparative Effect of the Plants Extract used on the Hematology of Diabetic Rats

The Packed Cell Volume (PCV) decreased significantly in *C. albidum*, and *M indica* while it increased significantly in diabetic untreated control, *L. inermis* and *A. sativum* though metformin did not show any alteration when compared to non-diabetic control. Red Blood Cell (RBC) values increased significantly in *L. inermis* group while it reduced significantly in *C. albidum* and *M. indica* when compared to other treated groups and the controls. haemoglobin (Hb), concentration followed similar trends as seen with RBC increasing significantly in *L. inermis* and *A. sativum* while it decreased significantly in *C. albidum* and *M. indica* when compared to the non-diabetic control. MCV and MCH decreased in all the treated groups when compared to non-diabetic control while the values of MCHC did not show any alteration across treatment groups compared to normoglycaemic untreated control (Table 4).

Total white blood increased significantly in *C. albidum*, *M. indica* and hyperglycaemic control (PC) while *A. sativum* showed non-significant increased values though *L. inermis* did show significant alteration when compared to normoglycaemic control (NC). Neutrophil increased significantly in groups; *M. indica*, *C. albidum* and metformin while *A. sativum* decreased significantly without much alteration in *L. inermis* treated group when compared to diabetic and non-diabetic controls. Lymphocytes increased significantly ($p<0.05$) *A. sativum* while other treatment groups showed non-significant decreased lymphocyte compared to normoglycemic control. The lymphocytes also showed non-significant increased values in diabetic untreated control (PC) but no significant alteration in all other treatment groups compared to normoglycaemic control. Mean platelet counts increased significantly in all the treatment groups while diabetic control did not show any alteration when compared to normoglycaemic control (Table 4).

Table 4: Haematology of Diabetic Wistar Rats Treated with Different Solvent Portioned Fraction of *Lawsonia inermis* Linn Leave and Oral Hypoglycaemic Agents

GRPS/ VALUE	NC	PC	LI	CA	AS	MI	MF
PCV	39.25 ± 2.87	42.00 ± 2.83	41.3 ±3.06	34.00 ± 7.21	41.33 ± 3.51	34.67 ± 6.11	39.33 ± 3.06
RBC	6.52 ± 0.57	6.95 ± 0.86	7.01 ± 0.67	5.39 ± 0.67	6.75± 0.63	5.98 ± 1.3	6.867 ± 0.46
HB	12.01 ± 1.37	13.15± 1.77	13.11 ± 1.77	10.20 ± 2.14	13.22 ± 2.1	10.90 ± 1.48	12.45 ± 1.22
MCH	18.35 ± 0.53	9.50 ± 10.97	14.05 ± 9.40	14.23 ± 9.49	14.63 ± 9.83	13.85 ± 9.37	13.58 ± 9.13

GRPS/ VALUE	NC	PC	LI	CA	AS	MI	MF
MCV	60.28 ± 1.20	43.33 ± 35.07	44.30 ± 29.56	47.48 ± 31.69	45.83 ± 30.56	43.93 ± 29.79	43.08 ± 29.15
MCHC	30.50 ± 1.27	31.45 ± 2.33	31.73 ± 2.20	30.03 ± 0.26	31.73 ± 2.37	31.63 ± 1.63	31.63 ± 1.63
WBC	5.91 ± 2.09	7.75 ± 3.18	5.23± 0.55	7.80± 1.93	6.20 ± 1.06	7.35 ± 1.57	7.59 ± 0.63
NEU	37.00 ± 9.49	39.50 ± 0.71	37.67 ± 7.51	41.00 ± 3.61	35.00 ± 7.00	43.33 ±9.07	41.00 ± 6.08
LYM	60.75 ± 10.37	59.00 ± 1.41	59.67 ± 8.51	57.67 ± 4.04	61.33 ± 7.57	55.33 ± 8.74	55.33 ± 5.69
PLT	183.5 ± 19.77	173.0± 24.04	197.7± 10.21	210.7± 5.51	204.3± 10.50	178.0± 9.54	190.3± 10.60

All values are expressed in Mean ± SD (standard deviation of mean). Significantly higher (P≤0.05)

Comparative Effect of the Plants used on the Serum Chemistry of Diabetic Rats

Table 5 showed the serum chemistry of diabetic rats which was treated with *Lawsonia inermis* (LI), *Chrysophyllum albidum (*CA*)*, *Allium sativum (*AS*)*, *Mangifera indica (*MI*)* and metformin.

Biochemistry

Alanine aminotransferase (ALT) level presented significant (p<0.05) increased values in hyperglycaemic control in addition to the treated groups except *L. inermis* that did not show any alteration when compared to non-diabetic control. Aspartate aminotransferase (AST) followed similar trends with diabetic control (PC) and all the treatment groups increasing significantly except *L. inermis* that did not show any alteration when compared to the non-diabetic control. Alkaline phosphatase (ALP) increased significantly in diabetic control (PC) when compared with all the treatment groups. There is a significantly increased values *C. albidum* and metformin when compared to other treatment groups. *L. inermis*, *A. sativum* and *M. indica* did not show significant alteration when compared to normoglycaemic control. Urea level increased non-significantly in hyperglycaemic untreated group while other treatment groups decreased significantly. *L. inermis* and *C. albidum* showed significant (p<0.05) reduced level compared to other treatment groups and normoglycemic control. Creatinine of diabetic untreated rats *C. albidum* and metformin increased significantly compared to other treatment and normoglycemic control (Table 5)

Table 5: **Biochemistry of Diabetic Wistar Rats Treated with Different Solvent Portioned Fraction of *Lawsonia inermis* Linn Leave and Oral Anti-Diabetic Agents**

GRPS/VALUE	NC	PC	LI	CA	AS	MI	MF
AST	21.28 ± 7.50	28.45± 0.21	21.53±10.72	24.57± 4.82	22.83± 1.42	21.43 ± 9.12	23.07± 8.03
ALT	33.35 ± 6.56	41.35± 0.35	34.70±7.597	37.87± 17.06	34.03± 5.746	36.33± 11.27	35.30±2.261*
ALP	23.43 ±17.81	26.00 ± 3.54	23.90± 6.56	24.60± 1.28	23.20± 2.72	23.97± 14.04	24.93±5.95
UREA	6.50 ± 2.36	7.55± 0.78	3.533±1.00	3.90 ± 0.62	4.00 ± 0.52	4.93 ± 0.81	4.00 ± 0.61
CREATININE	124.8 ±27.71	135.7± 61.45	119.4±9.431	121.1± 61.83	123.9± 89.08	10.07± 28.37	138.17±11.50

All values are expressed in Mean±SD (standard deviation of mean)
Significantly higher (P≤0.05)

Discussion

Medicinal activities of most plant are as a result of abundant presence of bioactive constituents such as tannins, phenols alkaloids and flavonoids (Aremu *et al.,* 2022). Most of these plants have their distinct set of secondary metabolites that serves as the basis for novel drug detection (Hussein *et al.,* 2019). The increasing use of plant-based medicines necessitates safety evaluations of all medicinal plants and LD_{50} is very crucial in this evaluation offering crucial insights into their safety and potential risks (Irinmwinuwa *et al.,* 2023). The LD_{50} of the four medicinal plants used in this study were not determined as the highest dose (5000 mg/kg) administered did not cause toxicological manifestation. The result showed that *L. inermis, A. sativum* are relatively safe compared to *C. albidum* and *M. Indica* as a result of general appearance of the tested rats. The acute toxicity result seen in this study agrees with various reports on the safety profile of these plants including; *L. inermis* (Aremu *et al.,* 2022); *A. sativum* (Khan *et al.,* 2022); *C. albidum* (Owusu-Darko *et al.,* 2024) and *M. indica* (Tajudeen *et al.,* 2023) who all confirms that these plants are relatively safe when administered at various toxicological dosages.

Unexplained weight loss has been linked to diabetes mellitus and typically develops as the disease progress due inadequate amount of insulin that stops the body's cells from glucose utilization (Dilworth *et al.,* 2021). This assertion is further confirmed from this study as the untreated hyperglycaemic control group had a significant weight loss (-13%) compared to all the treatment groups. This result is consistent with the work of (Chike-Ekwughe *et al.,* 2024) who reported a significant weight loss in untreated STZ-induced diabetic rats. Reports have shown that excessive accumulation of body fat can cause type 2 diabetes, and the risk of type 2 diabetes increases linearly with an increase in body mass index (Li *et al.,* 2022). The non-significant decreased weight observed in most of the extract treatment could contributes to their anti-diabetic activities of these medicinal plant. *L. inermis* showed the least weight gain when compared to *A. sativum, C. albidum, M. indica* and metformin (standard anti-diabetic drug).

This present study assessed the comparative and relative antidiabetic benefits of *L. inermis, C. albidum, A. sativum* and *M. indica.* Each plant extract demonstrated significant effectiveness just as metformin, and all of them dramatically lowered blood glucose levels, supporting their long-standing use in the treatment of diabetes. Since diabetes mellitus is becoming a major problem worldwide, alternative therapies that are affordable are seldomly required. The result obtained from this study agrees with various reports of (Aremu *et al.,* 2022) (*L. inermis*); (Alsuliam *et al.,* 2023) (*A sativum*); (Akanji *et al.,* 2023) (*C. albidum*); and (Villas Boas *et al.,* 2020) (*M. indica*) who all confirmed the anti-diabetic activities of these medicinal plants in diabetic model. Medicinal plants offer a promising natural alternative in the treatment and management of diabetes (Jugran *et al.,* 2021) and their mechanisms of action are usually multifaceted,

including the enhancement of insulin secretion, improvement of insulin sensitivity, inhibition of carbohydrate-digesting enzymes, reduction of oxidative stress and inflammation, regulation of lipid metabolism, and modulation of gut microbiota (Ahmed *et al.,* 2024). Result from this study showed that *L. inermis* possesses a significant anti-diabetic activity when compared to *A. sativum, C. albidum, M. indica* and Metformin.

Anaemia has been identified as a common feature and consequence of diabetes mellitus, and studies have demonstrated that the disease worsens, the immune system and certain blood parameters undergo considerable changes (Saad and Qutob, 2022). Reports have shown that medicinal plants offer a promising alternative therapy for managing the haematological alterations commonly observed in diabetic patients (Dangana *et al.,* 2024). The result obtained from this study showed that most haematological parameters (PCV, RBC and Hb) in treatment *L. inermis* and *A. sativum* did not show significant alteration compared to *C. albidum* and *M. indica* in relation to normoglycaemic control.

Diabetes mellitus is usually characterized by a defective neutrophilic, phagocytic, and microbicidal actions (Naiff *et al.,* 2021). Chronic hyperglycaemia can lead to low-grade inflammation, which may affect the function and number of white blood cells (Rudnicka *et al.,* 2021) as seen in the hyperglycaemic control. The values of WBC and its differentials (neutrophil and lymphocytes) increased in*, A. sativum* and *M. indica* while *L. inermis* did show substantial alteration when compared to normoglycaemic control.

Report have shown that diabetes mellitus is associated with a higher risk of thrombosis because persistently higher BGL can lead to increased platelet activation and aggregation (Aremu *et al.,* 2024) leading to a pro-thrombotic state that increases the risk of cardiovascular complications and stroke (Beura *et al.,* 2024). The result from this study revealed that the platelet counts in *C. albidum* and *A. sativum* increased significantly compared to *L. inermis, M. indica* and metformin. The untreated diabetic rats showed decreased platelet counts compared to all the treatment groups and non-diabetic control. This result agrees with the (Rodriguez and Johnson, 2020) who reported that insulin reduce platelet aggregation in diabetic subjects as evident in untreated diabetic control.

Medicinal plants have shown significant potential in modulating the serum chemistry of diabetic rats (Matalqah and Al-Tawalbeh, 2025). This is usually achieved by reducing blood glucose levels, improving lipid profiles, protecting liver function, and enhancing kidney wellbeing, Bioactive plant-derived compounds offer promising alternatives for diabetes management. Reports have shown that diabetes mellitus can impair both liver and kidney function leading to nephropathy (Ruiz-Ortega *et al.,* 2020). The result from this study showed a significant increased values AST, ALT, and ALP in rats treated with *C. albidum, A. sativum,* metformin compared to *L. inermis* and *M. indica* that showed slight decrease values to these hepatic markers indicating hepato-protective activities. This outcome is in line with (Aremu *et al.,* 2024) who reported that fractions *L. inermis* had decreased values in liver enzymes of treated diabetic rats. This result also agrees with (Adeneye *et al.,* 2015) who reported that *M. indica* attenuates increased liver enzymes of alloxan-induced diabetic rats. The result infers that both *L. inermis* and *M. indica* have more hepato-protective activities compared to *A. sativum* and *C. albidum*.

Uncontrolled blood glucose levels result increased serum urea and creatinine, which are considered important biomarkers and signify kidney dysfunction and the result from this study agrees with (Agrawal *et al.,* 2024) with significant increased urea and creatinine level in untreated rats *C. albidum* and metformin also showed increased level compared to *L. inermis, A. sativum* and *M. indica* in relation to normoglycemic control

CONCLUSION

The results obtained from this study support the use of *L. inermis, A. sativum, C. albidum* and *M. indica* as complementary or alternative treatments for diabetes mellitus due to their strong antidiabetic activities. It can be deduced that *L. inermis* possesses the most significant anti-diabetic activities with excellent modulatory effects on haematology and biochemistry when compared to *A. sativum, C. albidum* and *M. indica* and the standard drug (Metformin).

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