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Protective Effects of *Newbouldia laevis* Aqueous Leaf Extract Against Diabetes-Induced Biochemical and Oxidative Alterations in Rats

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ABSTRACT
Newbouldia laevis possesses several scientifically reported medicinal properties with potential therapeutic relevance in diabetes management. This study investigated the protective effects of aqueous leaf extract of Newbouldia laevis against diabetes-induced biochemical and oxidative alterations in experimental rats. Type 2 diabetes was induced in male rats, followed by treatment with extract at varying doses of 200, 400, and 800 mg/kg body weight, while glibenclamide (3 mg/kg) served as the standard drug. Renal, hepatic, lipid, haematological, and antioxidant parameters were evaluated. Diabetic rats showed significant ($p < 0.05$) elevations in urea, creatinine, liver enzymes, lipid profile parameters, and malondialdehyde levels, alongside reductions in antioxidant enzyme activities and haematological indices. Administration of N. laevis extract significantly ($p < 0.05$) ameliorated these alterations in a dose-dependent manner, with effects comparable to glibenclamide. The extract demonstrated potent antioxidant, antidiabetic, and organ-protective activities, particularly in the liver and kidneys. These findings suggest that aqueous leaf extract of Newbouldia laevis may serve as a promising natural therapeutic agent for the management of type 2 diabetes and its associated complications.

Keywords: Antioxidant activity, Biochemical alterations, Glibenclamide Organ protection, Oxidative stress, Type 2 diabetes

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycaemia resulting from defects in insulin secretion, insulin action, or both (Antar et al., 2023). A major clinical problem associated with the disease is its progressive development of systemic complications, including nephropathy, hepatopathy, dyslipidaemia, and haematological disturbances, which significantly contribute to morbidity and mortality (Dilworth et al., 2021). These complications are strongly linked to oxidative stress, a condition arising from excessive generation of reactive oxygen species (ROS) and a concomitant decline in endogenous antioxidant defence systems (Caturano et al., 2023).

Despite the availability of conventional antidiabetic drugs, long-term management of diabetes remains challenging due to adverse effects, limited efficacy in preventing complications, and increasing disease burden globally (Gieroba et al., 2025). This has intensified the search for safer and more effective alternative therapies, particularly from medicinal plants with established pharmacological relevance (Sharma et al., 2022). *Newbouldia laevis*, a plant widely used in African traditional medicine, has been reported to contain bioactive phytochemicals such as flavonoids, alkaloids, and phenolic compounds, which are associated with antioxidant, hypoglycaemic, and anti-inflammatory properties (Mbagwu et al., 2020; Ujah et al., 2022). Previous studies have demonstrated its therapeutic potential in various experimental disease models; however, its comprehensive protective effects against diabetes-induced multi-organ biochemical and oxidative damage remain insufficiently characterized.

Therefore, the aim of this study was to evaluate the protective effects of aqueous leaf extract of *Newbouldia laevis* on biochemical and oxidative alterations in experimentally induced diabetic rats. The study further seeks to clarify its modulatory effects on renal, hepatic, lipid, haematological, and antioxidant parameters under diabetic conditions.

This work contributes to knowledge by providing integrated experimental evidence of the systemic protective effects of *Newbouldia laevis* against diabetes-induced biochemical and oxidative dysfunction. It also strengthens the scientific basis for its traditional use and highlights its potential as a natural therapeutic candidate for managing diabetes-associated complications.

MATERIALS AND METHODS

Collection and Authentication of Plant Material

Fresh leaves of *Newbouldia laevis* were harvested in April 2025 from a farm settlement in Umuahia North. The plant material was taxonomically identified and authenticated by Mr. Pipi in the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture Umudike, Abia State Nigeria. A voucher specimen (Ref. No. 20/395NL) was subsequently deposited in the departmental herbarium for future reference and documentation.

Preparation of Plant Extract

The freshly collected leaves were thoroughly rinsed with distilled water and air-dried under shade for a period of seven

days. The dried leaves were subsequently ground into coarse powder using a Waring blender and preserved in a sterile airtight container. Approximately 100 g of the powdered plant material was macerated in 500 mL of distilled water in a glass container, with intermittent stirring to enhance extraction efficiency. The mixture was allowed to stand at room temperature for 24 h before being filtered successively using clean muslin cloth and Whatman No. 1 filter paper. The filtrate was freeze-dried at a temperature of ≤ -40°C. The dried aqueous extract was then stored in a sterile airtight container at 4 °C until required for subsequent biochemical analyses.

Acute Toxicity Study

The acute toxicity evaluation of the aqueous leaf extract of *Newbouldia laevis* was conducted using the method described by Lorke. The median lethal dose (LD_{50}) of the extract was determined based on observed mortality and survival patterns following extract administration.

Phytochemical Analysis of Aqueous *Newbouldia laevis* Leaf Extract

Qualitative phytochemical screening of the aqueous leaf extract of Newbouldia laevis was carried out to determine the presence or absence of selected bioactive constituents, including alkaloids, tannins, flavonoids, phenols, terpenoids, saponins, cardiac glycosides, and steroids. The analyses were performed using established standard procedures as described by Harborne (1973, 1984, 1998), Sofowora (1993), and Trease and Evans (2002).

Induction of Diabetes

Experimental diabetes was induced in overnight-fasted male Albino rats by administering a single intraperitoneal injection of alloxan monohydrate at a dose of 120 mg/kg body weight. Following alloxan administration, the animals were provided with 5% glucose solution to minimize the risk of acute hypoglycemia. Seventy-two (72) hours after induction, fasting blood glucose levels were assessed, and rats exhibiting glucose concentrations greater than 250 mg/dL were considered diabetic and selected for the study.

Experimental Animals and Study Design

Adult male Albino rats were maintained under standard laboratory conditions with free access to feed and water and acclimatized before the experiment. The animals were randomly divided into six groups (n = 6): normal control, diabetic control, diabetic rats treated with glibenclamide (3 mg/kg), and diabetic rats treated with aqueous leaf extract of *Newbouldia laevis* at 200, 400, and 800 mg/kg body weight, respectively. Treatments were administered daily for 21 days to evaluate antidiabetic activity. At the end of the experiment, the rats were anaesthetized with urethane, sacrificed, and serum obtained after centrifugation for biochemical analyses.

Ethical Approval

All experimental procedures involving the use of animals were carried out in compliance with established institutional ethical guidelines for the care and use of laboratory animals.

Biochemical Analysis

Serum samples obtained from the experimental animals were used for the assessment of hepatic, renal, electrolyte, lipid profile, and oxidative stress biomarkers using standard analytical procedures. Liver function marker enzymes, including alanine aminotransferase (ALT) and aspartate aminotransferase (AST), were determined according to the method of Reitman and Frankel, while alkaline phosphatase (ALP) activity was assayed using the method described by GSCC. Renal function indices, namely urea and creatinine, were estimated following the methods of Fawcett and Scott and Bartels and Bohmer, respectively.

Serum electrolyte concentrations, including chloride, sodium, potassium, and bicarbonate ions, were determined using established standard methods, with bicarbonate estimation carried out according to the procedure described by Tietz. Lipid profile parameters comprising total cholesterol, triacylglycerol, and high-density lipoprotein cholesterol (HDL-C) were analysed using the methods of Allain, Fossati and Prencipe, Grove, and Burstein. Low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) concentrations were calculated using the formula described by Friedewald.

Oxidative stress and antioxidant biomarkers including superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), reduced glutathione (GSH), and malondialdehyde (MDA) were assayed according to the methods of Misra and Fridovich, Cohen, Tietze, Flohe and Gunzler, and Ohkawa, respectively.

Measurement of Haematological Parameters

Blood samples collected through cardiac puncture were transferred into ethylenediaminetetraacetic acid (EDTA) anticoagulated sample tubes using a sterile 5 mL syringe. The samples were subsequently used for the determination of various haematological indices, including red blood cell (RBC) count, total white blood cell (WBC) count, haemoglobin concentration (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC), following the procedures described by Laposata and McCaffrey (2022). Haematological analyses were performed using an automated haematology analyser manufactured by Coulter Electronics, Luton, Bedfordshire, United Kingdom.

Statistical Analysis

Data obtained from the study were expressed as mean ± standard error of the mean (SEM). Statistical analysis was performed using IBM SPSS Statistics version 20. Differences among experimental groups were evaluated using one-way analysis of variance (ANOVA), followed by post hoc multiple comparison test. Statistical significance was accepted at $p < 0.05$.

RESULTS AND DISCUSSION

Results

LD_{50} of Aqueous Extract of Newbouldia laevis Leaf

Table 1: Outcome of Acute Toxicity Study of Aqueous Extract of *Newbouldia laevis* Leaf

Dose (mg/kg b.w.t)	No. of rats	No. of deaths	Survival	Mortality ratio
10	3	0	3	0/3*
100	3	0	3	0/3*
1000	3	0	3	0/3*

Dose (mg/kg b.w.t)	No. of rats	No. of deaths	Survival	Mortality ratio
1600	1	0	1	0/1*
2900	1	0	1	0/1*
5000	1	0	1	0/1*

*Number of deaths/surviving animals.

No mortality was observed in rats administered aqueous extract of *Newbouldia laevis* leaf at doses of 10, 100, 1000, 1600, 2900, and 5000 mg/kg body weight during the acute toxicity study. All animals survived the observation period, indicating that the oral LD_{50} of the extract is greater than 5000 mg/kg body weight.

Phytochemical Constituents of the Aqueous Extract of *Newbouldia laevis* Leaf

Phytochemical analysis of the aqueous extract of *Newbouldia laevis* leaf qualitatively confirmed the presence of alkaloids, tannins, flavonoids, phenols, terpenoids, saponins, cardiac carbohydrates, and steroids (Table 2)

Table 2: Phytochemical Constituents of Aqueous Extract of *Newbouldia laevis* Leaf

Phytochemical Constituents	Aqueous Extract of *Newbouldia laevis* leaf
Alkaloids	++
Tannins	+
Flavonoids	+
Phenols	+
Terpenoids	+
Saponins	+
Cardiac glycosides	+
Steroids	+

Key: + = detected

The oral median lethal dose (LD_{50}) of aqueous *Newbouldia laevis* leaf extract was greater than 5000 mg/kg. No death was recorded at the maximum dose. The preliminary phytochemical tests on the extract gave positive results to alkaloids, tannins, flavonoids, phenols, terpenoids, saponins, cardiac glycosides, and steroids.

Table 3: Effect of Aqueous Extract of *Newbouldia laevis* Leaf on Serum Liver Function Parameters in Alloxan-Induced Diabetic Rats

Groups	Treatment	Total protein (g/dL)	Albumin (g/dL)	ALT (IU/L)	AST (IU/L)	ALP (IU/L)	Total bilirubin (mg/dL)
1	Normal control	6.05 ± 0.08^{b}	3.25 ± 0.06^{b}	24.75 ± 1.03^{a}	37.00 ± 1.47^{a}	78.25 ± 1.38^{a}	0.61 ± 0.01^{a}
2	Diabetic control	5.07 ± 0.09^{a}	2.57 ± 0.04^{a}	88.00 ± 1.96^{e}	115.00 ± 3.76^{d}	161.25 ± 5.79^{d}	1.28 ± 0.03^{c}
3	Diabetic + Glibenclamide (3 mg/kg body weight)	6.04 ± 0.06^{b}	3.25 ± 0.12^{b}	48.00 ± 1.68^{bc}	51.25 ± 1.31^{b}	107.00 ± 2.48^{b}	0.82 ± 0.01^{b}
4	Diabetic + *N. laevis* extract (200 mg/kg body weight)	5.90 ± 0.06^{b}	3.16 ± 0.05^{b}	53.50 ± 1.94^{d}	59.00 ± 1.68^{c}	118.50 ± 3.38^{c}	0.78 ± 0.03^{b}
5	Diabetic + *N. laevis* extract (400 mg/kg body weight)	6.11 ± 0.11^{b}	3.19 ± 0.01^{b}	49.75 ± 2.25^{cd}	51.75 ± 2.29^{b}	113.00 ± 1.08^{bc}	0.77 ± 0.01^{b}
6	Diabetic + *N. laevis* extract (800 mg/kg body weight)	6.09 ± 0.02^{b}	3.35 ± 0.04^{b}	43.75 ± 0.85^{b}	47.25 ± 1.31^{b}	109.00 ± 1.87^{bc}	0.77 ± 0.01^{b}

Alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase (ALP). Values are expressed as mean ± standard error of the mean (SEM). Values on the same column with different superscripts are statistically significant at $p < 0.05$.

Significant ($p < 0.05$) increases in ALT, AST, ALP, and bilirubin were observed in diabetic rats, accompanied by reduced ($p < 0.05$) protein levels. Extract treatment significantly ($p < 0.05$) reversed these alterations, with the 800 mg/kg dose showing values comparable to the normal control.

Table 4: Effect of Aqueous Extract of *Newbouldia laevis* Leaf on Serum Renal Function Parameters in Alloxan-Induced Diabetic Rats

Groups	Treatment	Urea (mg/dL)	Creatinine (mg/dL)	Na^{+} (mmole/L)	K^{+} (mmole/L)	Cl^{-} (mmole/L)	HCO_3^{-} (mmole/L)
1	Normal control	18.48 ± 0.62^{a}	0.72 ± 0.03^{a}	129.03 ± 1.00^{b}	4.51 ± 0.02^{c}	86.40 ± 0.65^{bc}	19.88 ± 0.09^{a}
2	Diabetic control	31.63 ± 1.65^{d}	1.17 ± 0.04^{d}	123.75 ± 0.26^{a}	4.29 ± 0.02^{a}	81.95 ± 0.50^{a}	20.48 ± 0.09^{b}
3	Diabetic + Glibenclamide (3 mg/kg body weight)	23.70 ± 1.10^{b}	0.88 ± 0.02^{b}	129.10 ± 0.44^{b}	4.47 ± 0.02^{bc}	87.48 ± 0.36^{bcd}	19.98 ± 0.10^{a}
4	Diabetic + *N. laevis* extract (200 mg/kg body weight)	26.58 ± 0.36^{c}	0.97 ± 0.03^{c}	127.90 ± 0.75^{b}	4.41 ± 0.04^{b}	86.30 ± 0.23^{b}	20.13 ± 0.08^{a}
5	Diabetic + *N. laevis* extract (400 mg/kg body weight)	24.38 ± 0.74^{bc}	0.87 ± 0.01^{b}	128.35 ± 0.26^{b}	4.42 ± 0.03^{bc}	88.30 ± 0.41^{d}	19.98 ± 0.09^{a}

Groups	Treatment	Urea (mg/dL)	Creatinine (mg/dL)	Na^+ (mmole/L)	K^+ (mmole/L)	Cl^- (mmole/L)	HCO_3^- (mmole/L)
6	Diabetic + *N. laevis* extract (800 mg/kg body weight)	23.18±0.53^{bc}	0.85±0.01^{b}	129.28±0.28^{b}	4.49±0.04^{bc}	87.88±0.57^{cd}	20.03±0.09^{a}

Sodium ion (Na^+), potassium ion (K^+), and chloride ion (Cl^-). Values are expressed as mean ± standard error of the mean (SEM). Values on the same column with different superscripts are statistically significant at $p < 0.05$.

Diabetic rats showed significant ($p < 0.05$) elevations in urea and creatinine. Electrolyte imbalance ($p < 0.05$) was also evident. Treatment with *N. laevis* extract significantly ($p < 0.05$) reduced urea and creatinine levels and restored ($p < 0.05$) electrolyte balance in a dose-dependent manner.

Table 5: Effect of Aqueous Extract of *Newbouldia Laevis* Leaf on Serum Lipid Profile Parameters in Alloxan-Induced Diabetic Rats

Groups	Treatment	Total cholesterol (mg/dL)	HDL-C (mg/dL)	Triglycerides (mg/dL)	LDL-C (mg/dL)	VLDL-C (mg/dL)
1	Normal control	91.40±1.06^{a}	63.20±0.47^{c}	81.85±1.13^{a}	11.83±1.16^{a}	16.37±0.23^{a}
2	Diabetic control	119.88±1.71^{e}	59.78±0.47^{a}	106.15±1.58^{c}	38.87±2.13^{d}	21.23±0.32^{c}
3	Diabetic + Glibenclamide (3 mg/kg body weight)	107.80±1.12^{d}	60.63±0.81^{a}	96.70±2.04^{b}	27.84±1.32^{c}	19.34±0.41^{b}
4	Diabetic + *N. laevis* extract (200 mg/kg body weight)	101.05±1.01^{c}	61.65±0.83^{bc}	95.98±0.80^{b}	20.21±1.13^{b}	19.20±0.16^{b}
5	Diabetic + *N. laevis* extract (400 mg/kg body weight)	98.03±0.61^{bc}	62.90±0.19^{c}	96.35±0.45^{b}	15.86±0.81^{a}	19.27±0.09^{b}
6	Diabetic + *N. laevis* extract (800 mg/kg body weight)	96.38±0.85^{b}	62.33±0.53^{bc}	94.33±0.32^{b}	15.19±1.34^{a}	18.87±0.06^{b}

HDL-C (High-Density Lipoprotein Cholesterol), LDL-C (Low-Density Lipoprotein Cholesterol), VLDL-C (Very-Low-Density Lipoprotein Cholesterol). Values are expressed as mean ± standard error of the mean (SEM). Values on the same column with different superscripts are statistically significant at $p < 0.05$.

Diabetic rats exhibited significant ($p < 0.05$) dyslipidaemia characterized by increased total cholesterol, triglycerides, LDL-C, and decreased HDL-C. Treatment with *N. laevis* extract significantly ($p < 0.05$) improved lipid profile, when compared to the diabetic rats.

Table 6: Effect of Aqueous Extract of *Newbouldia Laevis* Leaf on Serum Antioxidant Enzymes and Markers in Alloxan-Induced Diabetic Rats

Groups	Treatment	GSH (U/mL)	GPx (U/mL)	SOD (U/mL)	CAT (U/mL)	MDAx10^{-3} (mmole/mL)
1	Normal control	14.88±0.45^{c}	53.75±1.80^{d}	34.00±0.91^{b}	16.50±0.96^{c}	0.22±0.01^{a}
2	Diabetic control	10.59±0.18^{a}	42.50±1.85^{a}	27.25±1.03^{a}	13.00±0.58^{a}	0.93±0.02^{d}
3	Diabetic + Glibenclamide (3 mg/kg body weight)	13.51±0.47^{b}	46.00±1.08^{ab}	30.00±0.71^{a}	13.50±0.65^{ab}	0.46±0.03^{bc}
4	Diabetic + *N. laevis* extract (200 mg/kg body weight)	14.17±0.26^{bc}	48.50±1.26^{bc}	30.25±1.38^{a}	15.25±0.63^{bc}	0.49±0.02^{c}
5	Diabetic + *N. laevis* extract (400 mg/kg body weight)	14.92±0.24^{c}	50.50±1.94^{bcd}	33.75±1.31^{b}	16.75±0.48^{c}	0.40±0.02^{b}
6	Diabetic + *N. laevis* extract (800 mg/kg body weight)	15.11±0.10^{c}	51.25±1.49^{cd}	33.50±1.04^{b}	17.25±0.48^{c}	0.40±0.01^{b}

Reduced glutathione (GSH), Glutathione Peroxidase (GPx), superoxide dismutase (SOD), Catalase (CAT), and Malondialdehyde (MDA). Values are expressed as mean ± standard error of the mean (SEM). Values on the same column with different superscripts are statistically significant at $p < 0.05$.

A significant ($p < 0.05$) reduction in GSH, SOD, CAT, and GPx levels was observed in diabetic rats, alongside increased ($p < 0.05$) MDA levels. Treatment with *N. laevis* extract significantly ($p < 0.05$) enhanced antioxidant enzyme activities and reduced ($p < 0.05$) lipid peroxidation.

Table 7: Effect of Aqueous Extract of *Newbouldia Laevis* Leaf on Haematological Parameters in Alloxan-Induced Diabetic Rats

Groups	Treatment	RBC ($x10^6$/mm^3)	PCV (%)	Hb (g/dL)	WBC ($x10^3$/mm^3)	PLT ($x10^3$/mm^3)	MCV (fL)	MCH (pg)	MCHC (g/dL)
1	Normal control	6.47±0.12^{c}	43.75±0.63^{d}	15.50±0.20^{d}	8.65±0.12^{c}	347.75±1.75^{a}	67.70±0.62^{b}	24.00±0.49^{c}	35.44±0.40^{b}
2	Diabetic control	5.05±0.09^{a}	33.75±0.63^{a}	10.98±0.18^{a}	7.97±0.05^{a}	358.25±4.96^{a}	66.80±0.32^{ab}	21.73±0.16^{a}	32.52±0.11^{a}
3	Diabetic + Glibenclamide (3 mg/kg body weight)	5.78±0.07^{b}	38.00±0.82^{b}	13.18±0.12^{b}	8.35±0.10^{bc}	351.25±2.14^{a}	65.78±0.81^{a}	22.82±0.15^{b}	34.71±0.66^{b}
4	Diabetic + *N. laevis* extract (200	5.74±0.09^{b}	38.00±0.71^{b}	13.20±0.24^{b}	8.41±0.09^{bc}	352.25±3.12^{a}	66.25±0.23^{ab}	23.01±0.09^{b}	34.74±0.14^{b}

Groups	Treatment	RBC ($x10^6/mm^3$)	PCV (%)	Hb (g/dL)	WBC ($x10^3/mm^3$)	PLT ($x10^3/mm^3$)	MCV (fL)	MCH (pg)	MCHC (g/dL)
	mg/kg body weight)								
5	Diabetic + *N. laevis l* extract (400 mg/kg body weight)	5.81±0.10^{b}	38.50±0.87^{bc}	13.23±0.19^{b}	8.18±0.16^{ab}	349.25±2.95^{a}	66.31±0.71^{ab}	22.80±0.53^{b}	34.39±0.83^{b}
6	Diabetic + *N. laevis* extract (800 mg/kg body weight)	5.98±0.07^{b}	40.50±0.29^{c}	13.95±0.17^{c}	8.45±0.10^{bc}	350.00±3.42^{a}	67.79±0.33^{b}	23.35±0.09^{bc}	34.44±0.25^{b}

RBC (Red Blood Cells), PCV (Packed Cell Volume), Hb (Haemoglobin), WBC (White Blood Cells), PLT (Platelets), MCV (Mean Corpuscular Volume), MCH (Mean Corpuscular Haemoglobin), MCHC (Mean Corpuscular Haemoglobin Concentration). Values are expressed as mean ± standard error of the mean (SEM). Values on the same column with different superscripts are statistically significant at $p < 0.05$.

Diabetes induced significant ($p < 0.05$) reductions in RBC count, haemoglobin, and packed cell volume while the extract-treated groups showed significant ($p < 0.05$) restoration of these parameters.

Discussion

The present study investigated the protective effects of the aqueous leaf extract of *Newbouldia laevis* against diabetes-induced hepatic, renal, lipid, oxidative stress, and haematological alterations in male experimental rats. Overall, diabetes induction resulted in marked metabolic disruptions, including renal dysfunction, hepatocellular injury, dyslipidaemia, electrolyte imbalance, oxidative stress, and haematological abnormalities. However, treatment with the extract markedly ameliorated these alterations in a dose-dependent manner, with the higher doses showing effects comparable to glibenclamide. These findings suggest strong antidiabetic, antioxidant, and organ-protective potential of the extract.

Diabetes mellitus is characterized by persistent hyperglycaemia, which enhances the generation of reactive oxygen species (ROS). Excess ROS overwhelms endogenous antioxidant systems, leading to oxidative damage to lipids, proteins, and nucleic acids, and ultimately disrupting cellular and metabolic homeostasis (González et al., 2023). The ability of the extract to reverse these pathological changes indicates that its therapeutic action may be largely mediated through antioxidant mechanisms and improved metabolic regulation.

Diabetes-induced hepatocellular injury was evident from elevated ALT, AST, ALP, and bilirubin levels, alongside reduced total protein and albumin concentrations. These markers reflect membrane damage, impaired hepatic synthesis, and oxidative stress-mediated liver injury (Rafaqat et al., 2023). Treatment with the extract significantly restored liver enzyme levels and improved protein synthesis, indicating hepatoprotection. The effect is likely due to antioxidant activity, membrane stabilization, and improved glycaemic control, which reduces metabolic burden on hepatocytes. This result is consistent with the findings reported by Osigwe et al. (2017) and Okafor et al. (2020).

Diabetic control rats showed elevated serum urea and creatinine, indicating impaired renal function and reduced glomerular filtration rate. These changes are consistent with hyperglycaemia-induced oxidative stress, which damages glomerular and tubular structures and promotes nephropathy (Khandker et al., 2026). Treatment with the extract significantly reduced urea and creatinine levels, suggesting restoration of renal function and nephroprotection. The protective effect of the extract may be linked to phytochemicals such as flavonoids and phenolic compounds, which reduce oxidative injury and stabilize renal membranes. Similar observations were made by Osigwe et al. (2017), supporting the present result.

Electrolyte disturbances observed in diabetic rats, including altered sodium, potassium, chloride, and bicarbonate levels, reflect impaired tubular reabsorption and osmotic diuresis (Elsawy et al., 2025). The extract effectively normalized these parameters, indicating improved renal tubular function and acid–base balance.

Dyslipidaemia observed in diabetic rats was characterized by elevated total cholesterol, triglycerides, LDL-C, and VLDL-C, with reduced HDL-C. These changes are typical of insulin deficiency, which enhances lipolysis and hepatic lipid synthesis (Burgeiro et al., 2017). The extract significantly improved lipid profile indices, suggesting hypolipidaemic and anti-atherogenic effects. This may be attributed to improved insulin sensitivity, inhibition of cholesterol biosynthesis, and antioxidant protection against LDL oxidation.

Oxidative stress was evident in diabetic rats through decreased levels of SOD, CAT, GPx, and GSH, alongside elevated malondialdehyde (MDA). These findings confirm severe oxidative damage and weakened antioxidant defence systems (Bhatti et al., 2022). Treatment with the extract restored antioxidant enzyme activities and reduced MDA levels, demonstrating strong free radical scavenging activity. This effect is likely due to phytochemicals such as flavonoids, tannins, and phenolic compounds, which enhance endogenous antioxidant systems and inhibit lipid peroxidation. The result obtained in this study concurs with those of Osigwe et al. (2017) and Okafor et al. (2020).

Diabetic rats exhibited reduced RBC count, haemoglobin, and PCV, indicating anaemia likely caused by oxidative damage to erythrocytes and impaired erythropoiesis (Mahmoud, 2013). The extract significantly improved these parameters, suggesting enhanced red cell production and protection against oxidative haemolysis. Restoration of MCV, MCH, and MCHC further indicates normalization of erythrocyte morphology and haemoglobin content. WBC levels, reduced in diabetic control animals, were also improved, suggesting immunomodulatory effects. Overall, haematological improvements may be linked to antioxidant protection and improved renal function. The present finding corroborates the report of Osigwe et al. (2017).

The protective effects of the extract were dose-dependent, with 400 and 800 mg/kg producing the most pronounced improvements. The highest dose in particular showed effects comparable to glibenclamide, suggesting significant pharmacological potency. The overall therapeutic effect is likely mediated through multiple mechanisms, including antioxidant activity, improved insulin function, membrane stabilization, anti-inflammatory effects, and modulation of lipid metabolism.

CONCLUSION

Aqueous leaf extract of *Newbouldia laevis* significantly ameliorates diabetes-induced biochemical and oxidative alterations. The extract exhibits nephroprotective, hepatoprotective, hypolipidaemic, haematological, and antioxidant effects, supporting its therapeutic potential in diabetes management.

Declaration of Conflict Of Interest

The authors declare no conflict of interest.

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