RESEARCH PAPER

UV-B-Enhanced Mimosa pudica L. Ethanolic Extract Exhibits Dual Antidiabetic and Hepatoprotective Effects in Streptozotocin-Induced Diabetic Rats

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ABSTRACT

Diabetes mellitus is a prolonged illness characterized by raised blood glucose concentrations and associated complications such as dyslipidemia, oxidative stress, and reduced liver function. This study examines the therapeutic potential of ethanol extracts from untreated (MPC) and UV-B-exposed (MPT). Mimosa pudica plant leaves in diabetic rats induced by streptozotocin (STZ). Phytochemical analysis through total phenolic content (120.02±1.05mg GAE/g DW in control vs. 208.95 ± 2.01mg GAE/g DW in UV-B treated) and total flavonoid content (103.08 ± 0.70mg QE/g DW in control vs. 172.68 ± 1.23mg QE/g DW in UV-B treated) revealed significant enhancement induced by UV-B. Thin-layer chromatography (TLC) revealed unique phenolic and flavonoid compounds exhibiting greater band intensity in samples treated with UV-B. Both extracts enhanced plasma insulin levels, reduced fasting glucose, rectified lipid profile irregularities (total cholesterol, triglycerides, LDL-C, VLDL-C, while increasing HDL-C, and improved hepatic damage (ALT, AST, and ALP). Conspicuously, the MPT extract demonstrated enhanced effects, probably because of UV-B-induced increases in phenolics and antioxidants. UV-B exposure enhanced the phenolic levels and therapeutic properties of M. pudica in comparison to the untreated extract. These findings emphasize UV-B-treated M. pudica as a potential phytotherapeutic candidate for diabetes and associated metabolic disorders.

Keywords: UV-B treatment, antidiabetic activity, hepatoprotective effect, phytochemicals, lipid profile, liver enzymes, oxidative stress.

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INTRODUCTION

"Diabetes mellitus (DM)," long-term metabolic condition, results from inadequate insulin production, insulin resistance, causing ongoing hyperglycemia. It now impacts more than 400 million individuals globally, with the prevalence expected to rise due to sedentary habits and aging demographics (International Diabetes Federation, 2021). The primary categories encompass Type 1 diabetes, resulting from autoimmune destruction of β-cells, and Type 2 diabetes, characterized by β-cell dysfunction as well as insulin resistance. Both can trigger severe complications, including hepatic damage, retinopathy, nephropathy, neuropathy, and cardiovascular disorders (American Diabetes Association, 2023).

Hyperglycemia disrupts glucose and lipid metabolism while endorsing oxidative stress via extreme reactive oxygen species (ROS) assembly that destroys cellular macromolecules (Ceriello et al., 2022). Diabetic dyslipidemia—marked by elevated triglycerides, LDL-C, total cholesterol, along with reduced HDL-C—further increases cardiovascular risk (Goldstein et al., 2020). Liver function is also impaired in diabetic conditions, as reflected by elevated ALT, AST, and ALP levels (Rizvi et al., 2021). As result, plant-based alternatives rich in bioactive compounds—like flavonoids, alkaloids, tannins, phenolics—have attracted growing interest.

Although conventional drugs such as insulin and biguanides are widely used and effective, they often cause

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**Author for Correspondence: herdiani-s-p@fk.unair.ac.id* side effects and may lose efficacy with long-term use (Marathe et al., 2022). Consequently, plant-derived alternatives abundant in bioactive compounds, including flavonoids, alkaloids, tannins, phenolics-have garnered increased attention, all of that possess documented antidiabetic, antihyperlipidemic, hepatoprotective properties (Patel et al., 2020).

Mimosa pudica Linn. (“touch-me-not”) is traditionally used to manage diabetes and liver disorders, owing to its comfortable of bioactive constituents including mimosine, flavonoids, and tannins (Bajaj & Khan, 2012; Gharib et al., 2019). These compounds may reduce oxidative stress, improve lipid metabolism, and protect liver tissue, offering mechanistic benefits in direct diabetes-related complications.

Recent studies show that ultraviolet (UV-B) radiation can stimulate the production of phenolics and antioxidants in plants, thereby enhancing their therapeutic potential (Sarkar et al., 2021). However, limited research exists regarding the outcomes of UV-B revelation on the bioactive outline of *M. pudica.* UV-B treatment may strengthen the antidiabetic and hepatoprotective efficacy of plant extracts by boosting secondary metabolite accumulation, increasing their relevance as alternative or complementary therapeutic agents.

In this context, the current investigation focuses to investigate impact of UV-B radiation on improving antidiabetic or hepatoprotective properties of *M. pudica.* Streptozotocin-induced diabetic rats will be used to compare ethanol extracts from control plants (MPC) with those from UV-B-treated plants (MPT). Assessments will include blood glucose, insulin, lipid profile, liver enzymes, and antioxidant markers. This investigation will provide mechanistic insights into the potential of UV-B–enhanced M. pudica extracts as safer, plant-derived therapeutic alternatives to conventional treatments.

MATERIALS AND METHODS

Plant material

Certified seeds of *Mimosa pudica* Linn have been acquired from a commercial producer in Chennai. The seedlings were raised in the Botanical Garden of Pachaiyappa's College, Chennai. Two sets of seedlings were raised one for exposure to ambient solar radiation and the other for exposure to 20% UV-B enhanced solar radiation.

Preparation of plant extracts

The entire *M. pudica* plant was chopped into smaller sections, shade dried, pulverized into fine powder, and kept at 5°C until required. It was subsequently combined with ethanol at a concentration of 10%. Extraction process using ethanol has been carried out utilising Soxhlet apparatus (ME), followed by concentration via a vacuum evaporator; the yield was 9.3% w/w (ethanolic extract).

PHYTOCHEMICAL SCREENING

Total Phenolic Content

The total phenolic content has been measured utilising “Folin-Ciocalteu technique” (Siddiqui et al., 2017). To summarize, 0.5 mL of extract was combined with 4.5mL of distilled water, followed by addition of 0.5mL of saturated sodium carbonate and 0.2mL of Folin-Ciocalteu reagent. After adding 4.3mL of distilled water, blend has been left to incubate in dark at room temperature for one hour. The results have been signified as milligrams of gallic acid equivalents (GAE)/ gram of dry weight after absorbance has been measured at 725nm.

Total flavonoid Content

Complete flavonoid content is measured spectrophotometrically utilising aluminum chloride colorimetric method. Plant extracts, prepared in methanol or ethanol, interact with 2% $AlCl_3$ solution (using 0.5-1.0 mL) and are incubated for 30mins at room temperature to form stable yellow flavonoid-aluminum complex. The absorbance is recorded at 415nm utiliding UV-Vis spectrophotometer relative to a reagent blank without extract. The measurement depends on a calibration curve of quercetin or rutin standards as well as is represented as mg quercetin equivalents (QE) or rutin equivalents (RE) for each gram of extract or dry weight (Chang *et al*, 2002).

STRUCTURAL ELUCIDATION OF ISOLATED BIOACTIVE COMPOUNDS

Thin layer chromatography (TLC) of methanol extracts for phytochemical analysis

Methanol extracts were examined for phytochemicals using TLC. Precoated silica gel aluminum sheets (Merck TLC, silica gel 60 F_{254}, 20x20cm) were utilized in procedure. After being developed in a TLC chamber using appropriate solvent systems, plates have been allowed to air dry at ambient temperature. Spots were subjected to iodine vapors in an iodine chamber after being viewed under visible and UV light at 254 and 365nm (Harborne, 1998; Raaman, 2006).

Rf values have been recorded for all spots. Specific solvent systems included:

Toluene: Ethyl acetate: Triethylamine (7:2:1; volume/volume/volume)

Chloroform: methanol (9:1; v/v) for phenols

Toluene and ethyl acetate in a 7:3 (v/v) for the analysis of flavonoids

Ethyl acetate: hexane (1:9; v/v) for saponins

Toluene: diethyl ether (1:1; v/v).

$$R_f \text{ Value} = \frac{\text{Distance travelled by solute front (in cm)}}{\text{Distance travelled by the solvent front (in cm)}}$$

IN VIVO ANTIDIABETIC ACTIVITY

Collection and acclimatization of experimental animals

Male Wistar albino rats weighing between 20-30 grams have been obtained from "C.S. Jain College of Pharmacy" in Chennai, India, for this evaluation. For sixteen hours, these animals were kept in spacious, open cages, fed nutritious pellets, and given unrestricted access to water.

Maintenance of animals

Seven days prior to the examination, the animals were acclimated, and during the test period, the standard ambient conditions were upheld, including a temperature of (22±5°C), humidity was kept at 55±5% and the light and dark cycle was set to 12 hours each.

Acute oral toxicity study

An acute oral toxicity investigation involved 36 Wistar rats acclimatized for 5 days under standard laboratory conditions. Each animal was individually marked as well as housed in controlled temperature, humidity, 12-hour light/dark cycle. Following overnight fasting, the test substance was administered orally by gavage as a single dose, with a maximum volume of 1mL/100g body weight (or 2mL/100 g for aqueous solutions). Doses were calculated according to individual body weights, and food was withheld for 24 hours post-management.

For the first 30 minutes, every 4 hours on the first day, and every day after that for 14 days, the animals were closely observed to track indicators of toxicity, behavioral changes, and mortality.
Throughout, body weights and clinical evaluations were recorded. The research was approved by Institutional Animal Ethics Committee as well as followed OECD Guideline 423 (Acute Toxic Class Method) and got "Institutional Animal Ethics Committee" (IAEC Approval No. 18/321/PO/Re/S/01/CPCSEA, valid from November 24, 2023, to November 25, 2024).

Chemicals

Glibenclamide was purchased from Hoechst Pharmaceuticals and streptozotocin (STZ) from Sigma Chemical Co. (USA). Dosages were based on human therapeutic equivalence per FDA 2005 guidelines.

Induction of Diabetes mellitus

Following a 12-hour overnight fast, rats have been administered single intraperitoneal injection of streptozotocin (50mg/kg body weight) dissolved in physiological saline to induce diabetes (Srinivasan et al., 2005). The animal had unlimited access to food and drink following the injection.
Both the normal rats and the diabetic-induced rats continued to eat the same food during the research period. Measuring of plasma glucose levels 72 hours after streptozotocin treatment confirmed hyperglycemia in the experimental animals (Kumar *et al.*2010). Rats with dietary plasma glucose levels between 200 and 260mg/dL have been chosen for additional research.

Experimental protocol

In this study, 30 rats were utilized, consisting of 24 diabetic rats and 6 normal rats. The rats have been divided into 5 groups, with 6 animals in each group. Three days before the start of the trial, diabetes was established in the experimental rats.

Treatment protocol

The rats were divided into five groups, each with six rats.

Group 1: Control group (vehicle, normal saline, 1mL/kg/body weight/day, oral administrated orally) for 28 days (Normal control).

Group 2: Diabetic rats induced by single intraperitoneal injection of Streptozotocin (50mg/kg body weight) (Diabetic control).

Group 3: Diabetic rats that received an oral dose of 50mg/kg/body weight per day of the ethanol extract of control M. pudica at for 28 days (Treatment control).

Group 4: Diabetic rats that received an oral dose of 50mg/kg/body weight per day of the ethanol extract of UV-B induced M. pudica for 28 days (Treatment control).

Group 5: Diabetic rats that received an oral dose of the standard drug Glibenclamide at dose of 50mg/kg/body weight/day for 28 days (Positive control).

Sample collection

The rats have been put to death after the experiment, and blood samples were taken. Plasma and serum have been seprated by centrifugation at 5000rpm for 10mins, which were then refrigerated for further examination. Plasma glucose levels were assessed before the treatment began and weekly throughout the treatment duration, specifically on days 7 and 28. The kidney, liver and pancreas were removed right away, cleaned of any remaining blood with ice-cold saline, and prepared for histological analysis.

Body weight

An electronic balance was utilized to record body weight of each animal both prior and subsequent experiment. The difference between the final and initial body weights was used to determine weight increase.

Biochemical analysis

Diabetic conditions were established in overnight-fasted rats by single intraperitoneal injection of streptozotocin (120mg/kg), following standard procedures. Rats with plasma glucose levels below 175mg/dL have been not included in study. An oral administration of varying doses of methanol extract of *M. pudica* were given daily until end of the study. On day 28, animals have been euthanized, blood along with tissue samples have been collected for the plasma glucose as well as insulin analysis.

Kidney, liver, pancreas tissues were finely chopped, placed into a glass homogenization tubes, and homogenized using a single-solvent system. After centrifuging the homogenates for 15 minutes at 5°C at 10,000rpm, supernatant has been collected for biochemical assays (Waynforth, 1980).

Estimation of blood glucose

Glucose oxidase method (Trinder et al., 1969) has been utilised to measure blood glucose levels using OneTouch Ultra (Johnson & Johnson) glucose test strip.

Estimation of Plasma insulin

Plasma insulin concentrations were determined utilising a solid-phase “enzyme-linked immunosorbent assay (ELISA),” following the procedure published by (Anderson et al.1993).

Estimation of serum lipid profile

Following a 28-day course of therapy, the rats had an overnight fast before being put to death via cervical dislocation. To separate serum, cardiac blood samples have been taken and centrifuged for 20 minutes at 3500 rpm. An automated blood chemistry analyzer (BT 2000 plus, Germany) was then used to measure the serum's levels of HDL-C, LDL-C, triglycerides (TG), VLDL-C, total cholesterol (TC).

Estimation of serum liver profile

Five milliliters of venous blood were drawn aseptically after an overnight fast, and they were sent to the lab on dry ice in less than an hour. Serum has been collected by centrifugation at 3000rpm for 5 minutes, aspartate aminotransferase (AST), levels of alanine aminotransferase (ALT), and alkaline phosphatase (ALP) have been determined utilising kinetic assays.

Histopathological Examination

All animals were put to rest on day 28, and tissues from the liver, pancreas, and kidney have been taken for histological analysis. Sections of pancreatic tissue have been stained with hematoxylin as well as eosin (H&E), seen under light microscope, and imaged for record.

Statistical analysis

The mean±SEM (n = 6 animals/group, with triplicates where available) is displayed for the data. One-way ANOVA was used to establish statistical significance, Newman-Keuls post-hoc test has been then performed. At p<0.05, differences have been measured significant, and at p<0.01 they have been considered very significant. Analyses have been done utilising GraphPad InStat (GraphPad Software Inc., San Diego, CA, USA).

RESULTS

Plants exposed to ultraviolet-B (UV-B) radiation often undergo significant biochemical and physiological adjustments, primarily by accumulating protective secondary metabolites like phenolics and flavonoids. These compounds not only shield plant tissues from photooxidative damage but also enhance their therapeutic potential by contributing antioxidant, anti-inflammatory, and antidiabetic properties. In the current investigation, *Mimosa pudica* plants were e to controlled UV-B irradiation to evaluate its impact on phytochemical enrichment and to determine whether such enhancement translates into improved biological activity. The following results summarize the influence of UV-B exposure on metabolite accumulation, chromatographic behavior, extract safety, and antidiabetic efficacy.

Phytochemical screening of ethanol leaf extracts from M. pudica

The *M. pudica* plants exposed to UV-B–treated(MPT) demonstrated significant rise in both total phenolic as well as flavonoid levels comparing with control(MPC) group. Total phenols increased from 120.02±1.0mg GAE/g DW in control to 208.95 ± 2.01 mg GAE/g DW under UV-B exposure, indicating an approximate 74% increase. Similarly, total flavonoid content rose from 103.08±0.70mg QE/g DW in control plants to 172.68±1.23mg QE/g DW in the UV-B–treated plants, indicating a 67% increase. This marked elevation in phenolic and flavonoid levels confirms that UV-B exposure strongly stimulates secondary metabolite production in *Mimosa pudica*, likely as part of its photoprotective and antioxidant defense mechanism (Table 1).

Table 1. Comparative evaluation of total phenolic and flavonoid contents in control and UV-B-stressed *Mimosa pudica* plants

Total phenol mg/g DW MPC of GAE		**Flavonoids mg/g DW MPT of QE**	
Control	**Treated**	**Control**	**Treated**
120.02 ± 1.05	208.95 ± 2.01	103.08 ± 0.070	172.68 ± 1.23

STRUCTURAL ELUCIDATION OF ISOLATED BIOACTIVE COMPOUNDS

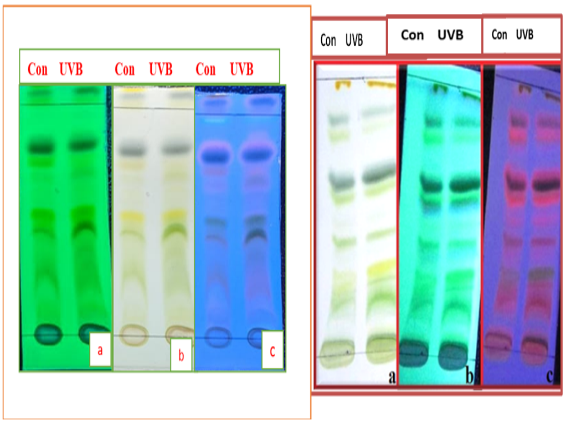
Thin-layer chromatography (TLC) of M. pudica profiling

Existence of secondary metabolites, such as phenols, is confirmed by TLC analysis of M. pudica leaves.

TLC Profiling of Phenolic and Flavonoid Compounds in Mimosa pudica

TLC profiling of *M. pudica* leaf extracts further reinforced these biochemical findings by revealing clear and quantifiable differences between the control and UV-B–treated samples. Phenolic constituents resolved at R_f values 0.34, 0.36, 0.52, and 0.55 displayed noticeably higher band intensity and sharper resolution in the UV-B lanes compared with the control (Table 2; Fig.1). This enhancement reflects a substantial upregulation of phenolic biosynthesis, a well-established adaptive response that involves activation of the phenylpropanoid pathway to counteract UV-B-induced oxidative pressure. The increased accumulation of phenolics corresponds to their well-documented roles as natural UV filters, antioxidants, and ROS scavengers, thereby helping to stabilize cellular structures and minimize photodamage.

Flavonoid separation further supported this trend, with compounds expressing R_f values 0.16, 0.31, 0.42, 0.71, and 0.76 showing strongly enhanced fluorescence and darker bands in the UV-B–treated extracts under UV illumination (Table 2; Fig.1). The pronounced amplification of bands at R_f 0.42, 0.71, and 0.76 indicates the induction of highly UV-responsive flavonoids, likely belonging to flavonol-rich subclasses known for their light-absorbing as well as antioxidant properties. Such compounds are typically synthesized in greater quantities when plants perceive UV-B signals through the UVR8 photoreceptor pathway, which initiates HY5-regulated transcriptional activation of flavonoid biosynthesis genes. Collectively, these chromatographic patterns (Fig.1) confirm that UV-B radiation acts as a potent biochemical inducer in *Mimosa pudica*, strengthening its antioxidant defense and enhancing secondary-metabolite–based resilience.



Phenol

Flavonoid

Fig.1. The TLC profile of phenol and flavanoid content in ethanolic extracts of dried *M. pudica* leaves.

a. Under 365 nm **b.** TLC envisioned under visible light and, **c.** Under 254 nm. **c.** 1= Control sample

2= treated sample, Solvent system: Chloroform: Methanol (9:1; v/v).

Table: 2 Differential R_f patterns of UV-B-responsive phenolic and flavonoid compounds detected through TLC in *Mimosa pudica* leaves.

TLC	Phenol	Flavonoid
R_f Values Obtained	0.34	0.16
	0.36	0.31
	0.52	0.42
	0.55	0.71
		0.76

The increased metabolite richness of the UV-B-treated extract (MPT) translated directly into improved biological activity. Notably, the MPT extract exhibited greater therapeutic efficacy than the untreated extract (MPC) in alleviating diabetes and associated metabolic complications. The UV-B-enriched amounts of flavonoids and phenolics, which are known to protect pancreatic β-cells, enhance antioxidant status, control glucose metabolism, are the cause of this increased activity.

In vivo Antidiabetic activity

The greater effectiveness of UV-B-treated *M. pudica* extracts (MPT) over untreated ones (MPC) in alleviating diabetes and associated complications stems mechanistically from UV-B-driven alterations in secondary metabolite composition, yielding enhanced physiological and molecular results.

Toxicity Assessment:

Acute toxicity testing of MPC and MPT extracts in Wistar rats revealed that both were safe, with only mild toxicity observed up to 1500 mg/kg body weight, thereby validating their suitability for further biological evaluations. This established the safety profile of both extracts, enabling their progression to antidiabetic assessments. Diabetes was experimentally produced with single intraperitoneal injection of streptozotocin (STZ), with the treatment success measured by variations in body weight, plasma insulin, blood glucose levels, lipid profile, liver enzyme activity.

Effect on Body Weight:

Rats with STZ-induced diabetes (Group II) had considerably higher fasting blood glucose levels, marked reductions in body weight in comparison to the non-diabetic control group (Group I), as shown in Table 3. Administration of MPC (Group IV) and MPT (Group V) extracts led to better weight gain and improved metabolic function. Of the treated groups, MPT had the most notable positive effect, outperforming both MPC and the diabetic control group (Group III). Moreover, MPT demonstrated more effective reduction in blood glucose-levels, in MPT group close to normal values ($p < 0.01$). This enhanced efficacy likely arises from UV-B-triggered buildup of bioactive secondary metabolites, including flavonoids and phenolics, which promote insulin release and augment peripheral glucose uptake.

Table 3 . Impact of *M. pudica* ethanolic leaf extract on body weight, blood glucose and plasma insulin levels in experimental animals under various treatments

Groups	**Body weight (g)**		**Mean weight**	**Fasting Blood glucose (mg/dL)**			**Plasma insulin (µu/mL)**
	Initial	**Final**	**Gain (G□) / loss(L□) (g)**	**1st Day**	**14th Day**	**28th Day**	
Group I	174.50 ± 13.10	188.22 ± 12.20	13.72^{b}↑	97.80 ± 4.50^{b}	95.10 ± 5.10^{b}	89.50 ± 4.30^{b}	510 ± 3.00^{b}
Group II	245.50 ± 18.00	202.00 ± 16.00	43.50^{a}↓	178.00 ± 4.10^{a}	227.00 ± 22.50^{a}	237.00 ± 44.00^{a}	354 ± 21.00^{a}
Group III	223.00 ± 9.60	241.00 ± 13.10	18.00^{ab}↑	148.00 ± 5.00^{ab}	115.50 ± 6.50^{ab}	113.50 ± 6.50^{ab}	552 ± 15.00^{ab}
Group IV	219.50 ± 8.30	239.50 ± 8.50	20.00^{ab}↑	144.00 ± 5.00^{ab}	138.12 ± 12.00^{ab}	74.50 ± 3.50^{ab}	890 ± 20.00^{ab}
Group V	203.00 ± 5.80	246.50 ± 11.20	43.50^{ab}↑	138.00 ± 12.00^{ab}	132.00 ± 11.50^{ab}	73.50 ± 2.80^{ab}	656 ± 8.00^{ab}
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Effect on plasma insulin level

In Table 3, rats with diabetes (Group II) showed much lower plasma insulin levels differentiate to standard control group (Group I). Treatment with MPC (Group IV), MPT (Group V) extracts, and Glibenclamide (Group III) at 50 mg/kg significantly elevated plasma insulin levels in diabetic Group II animals ($p<0.05$). MPT treated group demonstrated higher increase in insulin levels than the MPC group, suggesting greater effectivenss**.** These findings suggest that UV-B-induced metabolites safeguard β-cells against oxidative stress injury along with enhance insulin secretion.

Effect on serum lipid profile

Table 4 demonstrates that rats with diabetes produced by STZ represented greater levels of total cholesterol (TC), triglycerides (TG), and low-density lipoprotein (LDL-C) and VLDL-C coupled with decreased high-density lipoprotein (HDL-C), when comparing with normal control rats. Additionally, these same rats were subsequently evaluated for the effects of therapy- groups receiving either MPT or MPC extracts (50mg/kg)- lipid profiles have been significantly improved ($p<0.05$) and appeared in reduced TG, VLDL-C levels, LDL-C, TC, elevated HDL-C levels. Overall, both MPC and MPT extracts had lipid lowering effects, with MPT having greater lipid lowering effects than MPC and nearly equivalent efficacy to Glibenclamide. UV-B-induced bioactive compounds mechanistically regulate hepatic lipid metabolism by promoting LDL clearance and suppressing triglyceride production.

Table 4. Impact of *M. pudica* on serum lipid profiles in normal and experimental groups

Groups	**Total Cholesterol (mg/dL)**	**Triglycerides (mg/dL)**	**LDL-C (mg/dL)**	**HDL-C (mg/dL)**	**VLDL-C (mg/dL)**
Group I	115 ± 12.0^{b}	105 ± 16.0^{b}	130 ± 4.00^{b}	180 ± 18.00^{b}	99 ± 15.0^{b}
Group II	285 ± 28.0^{a}	260 ± 21.0^{a}	215 ± 7.00^{a}	120 ± 9.00^{a}	152 ± 8.0^{a}
Group III	125 ± 13.0^{ab}	130 ± 22.0^{ab}	135 ± 10.00^{ab}	270 ± 6.00^{ab}	108 ± 7.0^{ab}
Group IV	160 ± 22.0^{ab}	185 ± 37.0^{ab}	170 ± 22.00^{ab}	115 ± 11.0^{ab}	110 ± 22.0^{ab}
Group V	135 ± 5.0^{ab}	140 ± 8.0^{ab}	140 ± 12.00^{ab}	155 ± 12.0^{ab}	115 ± 6.0^{ab}
P-Value	0.000	0.000	0.000	0.000	0.000

Effect on liver health status

Table 5 indicates that diabetic rats (Group II) exhibited elevated AST, ALT, and ALP levels, signifying liver dysfunction. Treatment with MPC and MPT extracts lowered these enzyme levels significantly ($p<0.05$). MPT group (Group V) presented further reductions in these parameters compared to MPC group (Group IV) or Glibenclamide treated groups. UV-B-induced metabolites likely confer hepatoprotective benefits by alleviating oxidative stress and fostering tissue repair.

Table 5. Impact of *M. pudica* ethanolic extract on serum liver enzymes in normal and experimental animals.

Groups	**ALT (U/L)**	**AST (U/L)**	**ALP (U/L)**
Group I	235 ± 6.0	245 ± 2.0	358 ± 0.2
Group II	352 ± 34.0^{a}	330 ± 3.1^{a}	420 ± 0.2^{a}

Group III	260 ± 3.0^{ab}	210 ± 1.4^{ab}	310 ± 3.0^{ab}
Group IV	267 ± 2.0^{ab}	190 ± 3.4^{ab}	292 ± 4.2^{ab}
Group V	200 ± 5.0^{ab}	182 ± 0.3^{ab}	270 ± 1.1^{ab}
P-Value	0.000	0.000	0.000

HISTOPATHOLOGICAL EXAMINATION

Histopathology study of kidney

The histopathological evaluation of kidney tissues revealed considerable variations between the groups. In control group, histology (Fig.2a) demonstrated normal histology with normal structure to the glomeruli with Bowman's capsule intact and normal organization of tubules. The STZ-induced diabetic rats (Fig.2b) showed pathological changes including glomerular endocapillary structures, mesangial proliferation, tubular degeneration and dilation. Moreover, interstitial blood vessels indicated a congested pathological condition indicative of renal injury. The standard drug Glibenclamide provided revised progress in renal architecture (Fig.2c). Rats treated with ethanol extract of *M. pudica* (Fig.2d) and *M. pudica* (Fig.2e) showed mild mesangial proliferation, intact Bowman's capsule, and only mild degeneration of tubules. The findings revealed that *M. pudica* provided some degree of protection to counter the effects of diabetes. However, both *M. pudica* ethanol extracts were only somewhat effective in this regard compared to Glibenclamide. UV-B-induced antioxidant compounds likely mediate renoprotective effects by diminishing oxidative and inflammatory injury in kidney tissue.

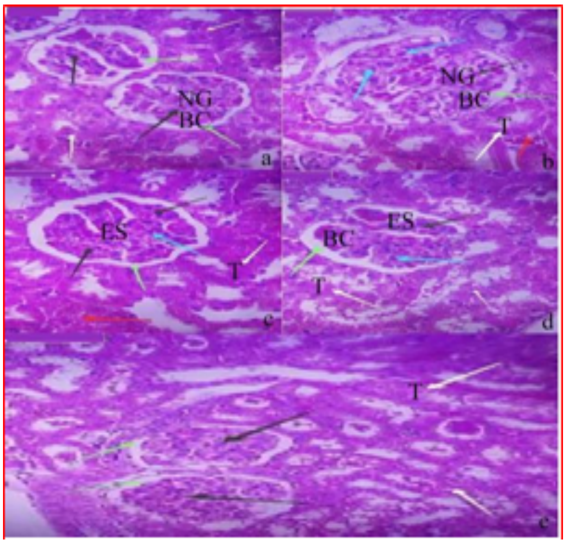


Fig.2 Photomicrograph of kidney cross section stained with haematoxylin and eosin (x400 magnification).

a, e- Section from kidney show normal glomeri (Black arrow), Bowman's capsule (green arrow), tubules (white arrow).

b-Sections from kidney, glomeruli showed endocapillary structures (black arrow) mesangial proliferation (blue arrow), normal Bowman's capsule (green arrow), tubular degeneration and dilatation (white arrow), interstitial congested blood vessels (red arrow)

c, d -Sections from kidney, glomeruli showed endocapillary structures (black arrow) mild mesangial proliferation (blue arrow), normal Bowman's capsule (green arrow), mild tubular degeneration (white arrow), interstitial congested blood vessels.

Histopathology study of pancreas

The pancreases of Streptozotocin-induced diabetic rats (Fig.3b) displayed inflammatory infiltrates, primarily made up of lymphocytes and plasma cells. These immune cells caused damage to the acinar tissue. Despite this, the islets of Langerhans stayed intact. In contrast, the control group's pancreases (Fig.3a) had normal islet cells and intact exocrine tissue, with no signs of inflammation. Glibenclamide (Fig.3c) mediated considerable restoration of damaged islets. Both MPC and MPT (Figs.3d & 3e) likewise restored, with restored normal islet cells and normal exocrine acini structure, although MPT appeared to provide better recovery compared to MPC. UV-B-driven enhancement of secondary metabolites likely alleviates β-cell oxidative stress and inflammation, aiding insulin recovery.

Histopathology study of liver

The control group (Fig.4a) displayed normal portal triad structures (portal vein, bile ducts, and hepatocytes), with no notable pathologies observed in liver sections from control rats under light microscopy. In the streptozotocin-caused diabetic rats (Fig.4b), there were evidence of periportal inflammatory infiltrate, mild fibrosis, portal vein involvement, bile duct hyperplasia, and altered sinusoids and hepatocyte structure. Rats administered glibenclamide (control for metabolites) (Fig.4c) also demonstrated mild periportal inflammatory infiltrate, along with continued mild liver structural alterations. Rats administered MPC and MPT extracts (Figs.4d & e) however showed normal liver architecture and significant tissue re-generation; the MPT group showing particularly improved regeneration of liver structure. This improved recovery corresponds anti-inflammatory and antioxidant effects of UV-B-induced metabolites.

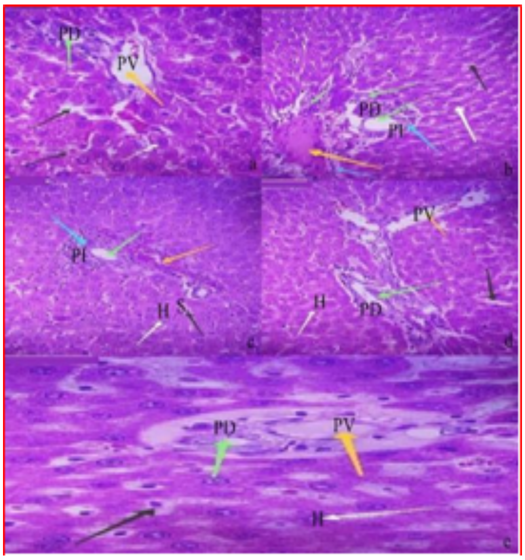


Fig.3 Photomicrograph of pancreas cross section stained with haematoxylin and eosin (x400 magnification).

a, c, d, e-Sections from pancreas showed normal islet cells (white arrow), exocrine pancreatic acini are normal (black arrow) b- Sections studied show pancreas, with inflammatory infiltrates (red arrow) mainly of lymphocytes and few plasma cells in the exocrine pancreatic focus, which are seen destructing the acini, some of them with Inspissated secretions inside (white arrow), islets of langerhan (white arrow) appear normal.

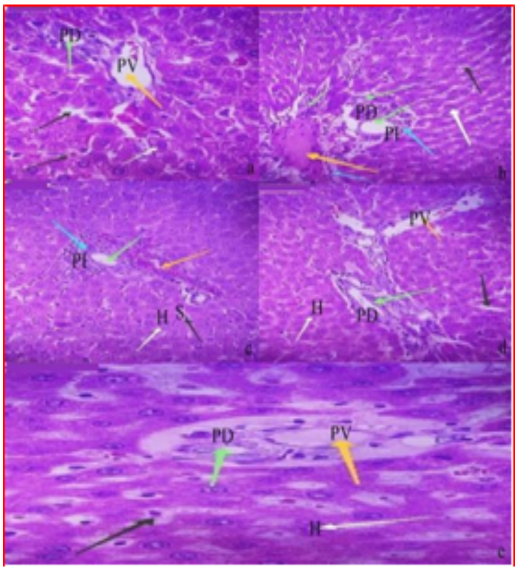


Fig.4 Photomicrograph of liver cross section stained with haematoxylin and eosin (x400 magnification).

a- Sections from liver showed normal portal structures, portal vein (yellow arrow), bile ducts (green Arrow), dilated sinusoids (black arrow), hepatocytes (white arrow), No significant pathology noted.

b- Sections from liver showed dense periportal inflammation and mild fibrosis (blue arrow), portal vein is congested (yellow arrow), bile ducts Proliferation (green Arrow), sinusoids (black arrow), hepatocytes (white arrow).

c- Showed mild periportal inflammation (blue arrow), portal vein is congested (yellow arrow), bile ducts Proliferation (green Arrow), sinusoids (black arrow), hepatocytes (white arrow),

d & e- Sections from liver showed normal portal structures, portal vein (yellow arrow), bile ducts (green Arrow), dilated sinusoids(black arrow), hepatocytes (white arrow). No significant pathology noted.

Mechanistic Insight:

UV-B acts as a phyto-elicitor, boosting synthesis of flavonoids, phenolics, and antioxidants in *M. pudica.* These metabolites drive antidiabetic and organ-protective effects via key pathways:

1. **ß-Cell protection and insulin secretion:**
Neutralizing ROS and curbing inflammatory injury in pancreatic islets.

2. **Lipid modulation:**
Suppressing hepatic cholesterol/triglyceride production while promoting LDL clearance.

3. **Lipid and kidney protection:**
Countering oxidative stress, inflammation, and fibrosis to support tissue repair. Overall, MPT outperforms MPC and glibenclamide, underscoring UV-B's role in enriching beneficial secondary metabolites.

DISCUSSION

The study investigated the therapeutic efficacy of standard (MPC) and UV-B–enhanced (MPT) ethanol extracts of *Mimosa pudica* in diabetic rats induced with streptozotocin (STZ). To understand the basis of their biological effects, phytochemical composition and chromatographic profiles were first evaluated, followed by assessments of metabolic, biochemical, and histological outcomes.

Phytochemical analysis of ethanol extracts of leaves of M. pudica

UV-B radiation shows a main part in increasing production of secondary metabolites like flavonoids as well as phenols in plants. This enhancement occurs through UV-mediated molecular signalling pathways, particularly the UVR8 receptor, which activates protective compound formation upon UV-B perception (Tilbrook & Jenkins, 2013). Several studies on medicinal plants have demonstrated that controlled UV-B exposure significantly increases phytochemical accumulation, improving antioxidant and pharmacological potential (Chen et al., 2018). As, UV-B treatment elevated flavonoids like quercetin and kaempferol in Sideroxylon capiri callus cultures (Martínez-Silvestre & Perez-Corona, 2022), while similar increases in flavonols have been reported in grape and silver birch (Kumari & Prasad, 2013). Overall, these findings confirm UV-B as an effective elicitor capable of boosting phytochemical content in medicinal plants, with strong implications for agriculture, biotechnology, and pharmacology.

Thin-Layer Chromatography (TLC) Analysis

The TLC of the ethanolic extract from *M. pudica* leaves showed several phenolic secondary metabolites, with seven different compounds identified based on their *Rf* values. UV-B exposure resulted in nearly a twofold increase in these compounds relative to untreated plants, highlighting their role in stress adaptation and antioxidant defense. UV-B is also known to be more effective than UV-A in promoting secondary metabolite accumulation, as phenolic compounds respond rapidly to UV exposure post-harvest in plants such as Vaccinium and Brassica (Huyskens-Keil & Johnsons, 2010). This effect is closely linked to enhanced phenylalanine ammonia-lyase activity, which drives phenolic biosynthesis (Pluskota & Kloosterman, 2006). Similar UV-B-induced enhancements have been documented in *Artemisia annua, Vitis vinifera, Cuminum cyminum,* and *Curcuma caesia* (Ghasemi & Sadeghi, 2019; Jaiswal et al., 2020). Collectively, these results underscore UV-B as a strong elicitor that improves phytochemical yield and enhances pharmacological value.

The extract from UV-B–treated *M. pudica* (MPT) therefore possesses significantly higher levels of bioactive compounds than the untreated extract (MPC). These metabolites—particularly flavonoids and phenolics—contribute antioxidant, anti-inflammatory, enzyme-inhibitory, and insulin-sensitizing activities. As a result, MPT demonstrates greater potential for β-cell protection and regeneration, improved glucose uptake, lipid regulation, and enhanced liver and kidney recovery. This explains why MPT consistently outperforms MPC in antidiabetic, hypolipidemic, and organ-protective effects.

"Diabetes, a common pancreatic disorder, is expected to affect over 100 million individuals across the world, with numbers forecasted to be doubled by 2030 and heavily amplified in lower income countries, such as India, Bangladesh, and Pakistan. While there are synthetic medicines available, plant-based medicine that contain bioactive compounds including flavonoids and phenolics, with many own antioxidant properties, are still widely used (van Wyk AS and Prinsloo, 2020). Many of the plants used as antidiabetic agents are employed under traditional systems, such as Ayurveda and Unani (Pan *et al.* 2014; Kooti *et al.*2016). Recent findings confirms that M. pudica effectively inhibits α-glucosidase and α-amylase, outperforming standard drug acarbose in laboratory tests, and significantly lowers blood glucose levels in diabetic rats without causing hematological toxicity (Yupparach and Konsue, 2017; Lee et al., 2022). When combined with *Abutilon indicum*, *M. pudica* was found to enhance insulin secretion as well as glucose uptake by upregulating GLUT1/GLUT4 (Mahidol University, 2024). Furthermore, innovative methods utilizing *M. pudica* for the green synthesis of strontium nanoparticles have shown strong α-amylase inhibition with minimal cytotoxicity, comparable to acarbose (Kumar *et al.*2024). Although we have medicines such as thiazolidinediones and biguanides which are efficacious, side effects from these drugs, such as increased neurological and cardiovascular risks, have spurred interest in safer plant-based alternatives.

This study will investigate the antidiabetic effects of ethanol extracts from *M. pudica*, both ambient-grown (MPC) and UV-B treated (MPT). Previously, it was discovered that UV-B treatment of plants increases the phytochemical compounds, suggesting that MPT may have more potential as a treatment. While it is clear these days that natural remedies are being used more widely, their safety still needs to be established, and any establishment requires efficacy studies and toxicological studies (Gupta *et al.*2013). Results found in the acute toxicity studies of the current research found that there were no significant adverse effects from either the MPC or MPT ethanol extracts at 1500 mg/kg in female albino rats, such that the safety margin appeared to be satisfactory (Al-Salmani, 2025).

IN VIVO ANTIDIABETIC ACTIVITY

Effect on Body Weight

Induction of diabetes with STZ (Streptozotocin) results in significant loss in body weight due to impaired glucose utilization and increased protein and fat catabolism (Yang *et al.*2016; Szkudelski, 2021). Control diabetic rats had obvious weight loss, while rats treated with MPC, MPT, or glibenclamide (50 mg/kg) gained significant weight ($p<0.05$), indicating metabolic balance has improved in treated groups. MPT-treated rats regained slightly more weight, possibly due to greater amounts of secondary metabolites enhanced by exposure to UVB. STZ induces β-cell necrosis when it binds GLUT2 receptors and this hinders insulin secretion (Wu *et al.*2016). MPC and MPT treated rats showed slight antihyperglycemic effect, similar to glibenclamide (Wealth of India, 1992), indicating either retained insulin effectiveness or other mechanisms were employed. Interestingly, rats treated with MPT regained a bit more weight, which could be attributed to UV-B exposure that boosts phytochemical levels in *M. pudica*, thus augmenting its therapeutic effectiveness (Rajendiran *et al.*2017; Murugesan *et al.*2024). The weight gain in the treatment groups indicates their glucose metabolism had been restored and muscle wasting was reduced (Rines *et al.*2016).

Fasting Blood Glucose (FBG)

STZ-caused diabetic rats showed substantially elevated FBG levels. Treatment with 50 mg/kg MPC and MPT extracts markedly lowered glucose levels, comparable to glibenclamide, over 28 days. These effects may stem from enhanced glucose uptake, reduced hepatic output, and antioxidant properties, though exact mechanisms require further exploration (Morikawa *et al.*2021).

MPC and MPT also suppressed activity of α-glucosidase as well as α-amylase, leading to reduced in carbohydrate digestion and management of postprandial glucose spikes- consistent with recent findings indicating that extracts of *M. pudica*, particularly ethyl acetate fractions, effectively inhibit these enzymes *in vitro* (Sapkota *et al.*2022). This aligns with prior studies on antidiabetic plants (Etxeberria *et al.*2012; Oboh *et al.*2014). Additionally, treated rats exhibited weight recovery, likely due to enhanced glucose utilization and reduced protein catabolism. Importantly, the rats treated with MPT showed marginally better results, which may be attributed to UV-B exposure boosting secondary metabolite production—especially phenols, alkaloids, saponins, and other bioactive compounds-in *M. pudica* (Senthil Mani *et al.*2023). Additionally, male Sprague-Dawley rats were chosen due to their high sensitivity to STZ, ensuring a reliable induction of diabetes (Ghasemi and Jeddi, 2023).

Mechanism of Action

Glibenclamide declines glucose levels by exhilarating the secretion of insulin due to inhibition of the KATP channels (Fridlyand *et al.*2013). The MPC and MPT extracts may have similar or complementary mechanisms-enhancing peripheral uptake of glucose, inhibiting gluconeogenesis, or promoting regeneration of the β-cells (Sapkota *et al.*2022). Phytochemicals like flavonoids, alkaloids, and terpenes drive these effects, through their antioxidant properties, enzyme-inhibition, and insulin-sensitizing actions (Guleria and Vaidya, 2014; Salehi *et al.*2019).

The histological results support the hypoglycemic action of *M. pudica* extract. Biologically active phytochemical compounds from plants can provide a diversity of health benefits for humans (Saha,2019). Consequently, we propose that the antidiabetic action of *M. pudica* occurs via multiple mechanisms, including antioxidant action, insulin sensitization, enzyme inhibition, and protection of β-cells (Rajesh, 2013).

Oxidative Stress and Antioxidant Activity

Hyperglycemia causes an increase in ROS formation, which also increased oxidative stress, further impacting cellular structures (Singh *et al.*2022) - key element in development of type 2 diabetes (T2DM) aswell as its complications (Oliveira *et al.*2023). Diabetic conditions diminish antioxidant enzymes, which worsens lipid peroxidation and tissue injury (Chen *et al.*2021; Bhatti *et al.*2022). *M. pudica* extracts may alleviate these diabetic complications by scavenging free radicals and beneficially modifying antioxidant defenses, which is similar to underlying strategies in both modern medicine and traditional medicine, providing the resources to improve glycemia control and metabolic function (Subashini *et al.*2022). These findings align with strategies used in both modern and traditional medicine to improve glycemic control and metabolic function.

Effect on Plasma Insulin Levels

This current study revealed significant declines in plasma insulin concentration in STZ-caused diabetic rats because of β-cell destruction. The treatment with the MPC and MPT ethanolic extracts of *M. pudica* restored insulin levels. This elevation likely reflects β-cells regeneration and/or enhanced residual β-cell function (Frontiersin, 2024). The antioxidant potential of *M.pudica*, in conjunction with the MPT ethanol extract that was exposed to ultraviolet radiation, could have safeguard the β-cells from destruction and better insulin production and secretion (Gharib *et al.*2019). The MPC & MPT ethanol extracts lowered fasting glucose levels which could be due to that restoration of membrane integrity, thereby increasing the ability of insulin to facilitate glucose uptake. The histological sections from the pancreas of the *M. pudica* treatments provided evidence of pancreatic regeneration. Further, death analysis indicated the MPT ethanol extract restored pancreatic structure better than the MPC treatment, which could be a result of increases in phenolic compounds when using the MPT extract after exposure to UV radiation.

This study compliments the Ayurvedic tradition of successful polyherbal therapies for the treatment of diabetes by combining antioxidant support, cellular protection, and metabolic restoration.

Effect on Serum Lipid Profile

Diabetes often links to high blood sugar and high blood fats. This includes increased concentrations of cholesterol, LDL-C, triglycerides, VLDL-C. At the same time, HDL-C tends to decrease. These changes raise the risk of clogged arteries as well as heart disease (Kilari *et al.*2021; Yan *et al.*2023). In diabetes, surplus fatty acids undergo esterification in the liver to form triglycerides and cholesterol, which packed into lipoproteins and released-exacerbating the lipid imbalance (Heeren and Scheja, 2021; Chen *et al.*2022).

This study shows that treating diabetic rats with MPC and MPT changed their lipid levels significantly. The concentrations of total cholesterol, triglycerides, VLDL-C, LDL-C were reduced in these rats. At the same time, HDL-C levels increased. These changes suggest that the treatments helped improve their lipid profile. These improvements may be linked to enhanced insulin secretion, which activates lipoprotein lipase, facilitating triglyceride breakdown, as well as increased synthesis of HDL and receptor-mediated clearance of LDL (Alqahtani *et al.*2022). The lipid-lowering effects are also supported by possible antioxidant and polyphenolic content of the extracts which may inhibit HMG-CoA reductase and enhance hepatic LDL receptor activity (Sharma *et al.*2023). Such results corroborate recent studies showing that phytochemical-rich plant extracts positively influence lipid metabolism and restore lipid homeostasis in diabetic models (Kooti *et al.* 2016; Ahmad *et al.* 2024).

Effect on Liver profile

Diabetes mellitus commonly leads to elevated cholesterol, liver enzyme (ALT, AST, and ALP), and oxidative stress represent hepatic dysfunction and cardiovascular disease risk (Lozano-Paniagua *et al.*2021). In diabetic diabetic rats induced STZ, higher liver enzyme concentrations were associated to ROS and hepatic inflammation (Abdel-Emam and Ali, 2022; Zhao *et al.*2023). Treatment with *Mimosa pudica* extracts (MPC and MPT), resulted in a notable decline in liver enzymes comparable to glibenclamide, confirming their hepatoprotective effects (Abdel-Emam and Ali,2022). The study agrees with earlier studies showing plant containing antioxidants reduces liver enzyme levels to normal in diabetic disease models (Shibabaw *et al.*2019). In diabetic conditions, **catalase activity** typically decreases, but administration of *M. pudica* extracts restored catalase levels, reflecting improved **antioxidant defense** (Hayatou *et al.* 2023; Ouattara *et al.* 2024).

Given that liver dysfunction in diabetes increases gluconeogenesis and ketogenesis, increases in transaminases are an important sign to identify liver disease members (Li and Wang, 2022). Moreover, elevated urea and creatinine levels are hallmarks of kidney dysfunction; yet, *M. pudica* treatment significantly lowered them, underscoring the extract's renal potential effects (Hayatou *et al.*2023; Singh *et al.*2024). This highlights hepatoprotective and renoprotective act of MPC and MPT in STZ-caused diabetic rats. The extract from *M. pudica* that's been treated with UV-B (MPT) shows significantly better results compared to the untreated version (MPC). UV-B works as a phyto-elicitor, boosting the making of helpful secondary metabolites, comprising alkaloids, phenolics, flavonoids, saponins. These substances have strong antioxidant, anti-inflammatory, enzyme-inhibiting, and insulin-sensitizing effects. They support β-cell protection and regeneration, help the body absorb glucose, balance lipid levels, and assist in healing liver and kidney tissues. So, it's clear that UV-B treatment boosts the therapeutic potential of *M. pudica* compared to MPC, which explains why it shows better results in terms of antidiabetic, hypolipidemic, and organ-protective effects.

CONCLUSION

MPT performed better than MPC because UV-B, through its phytoelicitor action, upregulated bioactive secondary metabolites (flavonoids, phenolics, alkaloids, saponins) possessing high antioxidant, anti-inflammatory, enzyme-inhibitory, and insulin-sensitizing activities that safeguard β-cells, stimulate insulin secretion, enhance glucose utilization, decrease hepatic lipids, and can regenerate liver, kidney, pancreas. Both extracts enhanced fasting glucose tolerance, reducing the levels significantly with sustained action > 96 h post-dose; histopathology confirmed kidney, liver, and pancreas protection. The findings validate ethnomedicinal uses of *M. pudica* and encourage further in-depth pharmacological/clinical studies, with special emphasis on UV-B enhancement of bioactives for improved therapy.

The outcomes of this examination revealed that both the standard (MPC) and UV-B-treated (MPT) ethanol extracts of *Mimosa pudica* have subtle antidiabetic, antihyperlipidemic, and hepatoprotective action in streptozotocin (STZ)-caused diabetic male rats. These beneficial effects are applied to the vast area of synergistic phytochemicals, such as flavonoids and phenolics, found in both extracts, which promote insulin secretion, improve insulin sensitivity, restore lipid metabolic state, and protect the liver.

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