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In Vivo Anti-ulcerative Colitic and Mucosal Healing Efficacy of *Mimosa pudica* Root with Biochemical, Oxidative, Histopathological, and IL-10 Correlates

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Abstract

Background: Ulcerative colitis is a chronic, relapsing inflammatory bowel disorder primarily affecting the colonic mucosa. Despite advancements in immunosuppressive and biologic therapies, current pharmacological interventions are often limited due to adverse effects, limited efficacy, and high relapse rates. **Aim:** *Mimosa pudica* Linn., traditionally indicated for conditions resembling UC (such as *Pravahika* and *Raktatisara*), possesses anti-inflammatory, astringent, and mucosal healing properties. **Methods:** To investigate the therapeutic efficacy of *M. pudica* Linn. root powder in TNBS-induced model of ulcerative colitis in rats, focusing on clinical, biochemical, immunological (notably IL-10), haematological and histopathological markers. UC was induced in albino rats via intrarectal administration of TNBS (50 mg/kg). Animals were categorised into three groups: Normal Control, Disease Control, and Treatment Group (*M. pudica* Linn. root powder at 360 mg/kg orally for 10 days post-induction). Parameters assessed included Disease Activity Index (DAI), body weight, colon weight/length ratio, haematological markers, oxidative stress indicators (MPO, MDA, NO, GSH), anti-inflammatory cytokine IL-10, and histopathological scoring. **Results:** *Mimosa pudica* Linn. -treated rats showed significant clinical improvement as reflected by reduced DAI scores, preserved body weight, and normalised colon architecture. Biochemical assays revealed suppressed MPO, NO, and MDA levels alongside a marked decrease in IL-10 compared to the values into treatment group and an increase in GSH, indicating a dual anti-inflammatory and antioxidant mechanism. Histopathological examination confirmed mucosal regeneration, crypt recovery, and reduced leukocyte infiltration. **Conclusion:** *Mimosa pudica* Linn. exhibited potent anti-colitic effects through immunomodulatory (IL-10 mediated), antioxidative, and epithelial regenerative mechanisms. These support its traditional use and integration into contemporary ulcerative colitis management.

Major Findings: *Mimosa pudica* Linn. root powder demonstrated a disease-modifying effect in experimental ulcerative colitis by simultaneously targeting inflammation, redox imbalance, and mucosal integrity. The convergence of immunomodulatory and epithelial-restorative actions supports its role as a multi-pathway therapeutic candidate rather than a purely symptomatic intervention.

Keywords: Immunological Biomarkers, IL-10, *Mimosa pudica* Linn., Ulcerative Colitis

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1. Introduction

Ulcerative colitis is a long-term condition marked by repeated episodes of inflammation in the inner lining of the colon. Under the microscope, it typically shows shallow ulcers, damage to the glandular structures (crypts), and an increased presence of immune cells, indicating active inflammation. The disease aetiology

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remains multifactorial and idiopathic, involving a complex interplay of genetic predisposition, dysregulated immune responses, oxidative and nitrosative stress, dysbiosis, and disruption of epithelial barrier integrity[1]. Conventional therapeutic strategies often provide symptomatic relief but are hindered by limitations such as drug reactions, immunosuppression, cost burden, and incomplete mucosal healing. Consequently, there is a growing interest in exploring phytotherapeutics with immunomodulatory, antioxidant, and mucosal reparative properties[2].

Ayurveda, the traditional Indian system of medicine, *Mimosa pudica* Linn., traditionally recognised for its therapeutic utility, contains phytoconstituents with pronounced astringent and bitter pharmacodynamic profiles, along with bioactivities consistent with cooling and metabolically pungent transformations[3,4]. Preclinical and pharmacological evidence attributes to the plant haemostatic, anti-inflammatory, fluid-absorptive, and mucosal reparative properties, collectively suggesting a mechanistic congruence with the disrupted pathobiology and symptomatic expression of UC, and is therapeutically classified for actions including haemostatic (*Raktastambhaka*), anti-inflammatory (*Shothahara*), absorbent (*Grahi*), and wound-healing (*Vrana-ropaka*). These attributes theoretically align with the pathophysiological and symptomatic profile of UC.

While earlier studies show anti-inflammatory and antioxidant effects[5] of *M. pudica*, its actual effectiveness in a widely accepted animal model of colitis hasn't been thoroughly studied. This study aims to systematically investigate the therapeutic effects of *M. pudica* root powder using the TNBS-induced colitis model in albino rats, employing a comprehensive experimental design that evaluates a wide range of biochemical, histopathological, and clinical parameters.

The study evaluates: (1) Clinical Activity through the Disease Activity Index (DAI), a composite score incorporating weight loss, stool consistency, and rectal bleeding. This reflects the severity of colitis and treatment response. (2) Morphometric parameters, such as colon weight, length, and weight/length ratio, are macroscopic indicators of mucosal oedema, inflammation, and tissue hypertrophy. (3) Biochemical Indices of Inflammation and Oxidative Stress: Myeloperoxidase (MPO) activity quantifies neutrophil accumulation and mucosal inflammation. Nitric Oxide (NO) levels, primarily mediated by inducible nitric oxide synthase (iNOS), indicate nitrosative stress and epithelial disruption. Malondialdehyde (MDA) is a lipid peroxidation by-product and marker of oxidative tissue injury. Reduced Glutathione (GSH) levels represent endogenous antioxidant defence capacity; depletion reflects redox imbalance, and restoration signifies tissue recovery. (4) Haematological Parameters, including Haemoglobin (Hb), Erythrocyte Sedimentation Rate (ESR), Total Leukocyte Count (TLC), and Differential Leukocyte Count (DLC), serve as systemic indicators of blood loss, inflammation, and immune status. Anaemia and leucocytosis are common in UC, and their correction reflects systemic restoration. (5) Histopathological and Immmunological Evaluation, through blinded microscopic scoring of colon sections, assesses structural changes such as mucosal ulceration, crypt architecture, inflammatory infiltration, epithelial regeneration, and goblet cell restoration—providing morphological validation of therapeutic efficacy. From an integrative perspective, the observed upregulation of IL-10 correlates with the *Ayurvedic* concept of *Shamana* (pacification of aggravated regulatory functional factor of the body (*dosha*)), while the restoration of GSH reflects rejuvenation and tissue healing effects (*Rasayana*). Reduction in MPO, NO, and MDA aligns with blood purification and inflammation control (*Shothahara* and *Raktaprasadana*), while improvements in histological architecture mirror the classical action of *Vrana-ropana*. The normalisation of haematological profiles reflects *Rakta-shuddhi* and systemic haemostasis promoted by the *Raktastambhaka* property of *M. pudica* Linn.

Thus, this study bridges *Ayurvedic* pharmacodynamics with contemporary immunological and biochemical insights, reinforcing the utility of *M. pudica* as a multifactorial intervention in ulcerative colitis. Through simultaneously targeting immunoregulation, oxidative stress reduction, mucosal healing, and symptomatic relief, *M. pudica* Linn. demonstrates promise as a complementary strategy in integrative Inflammatory Bowel Disease (IBD) therapeutics.

The present study aims to evaluate the anti-colitic and mucosal restorative effects of *M. pudica*

Linn. root powder in a TNBS-induced ulcerative colitis rat model by assessing clinical disease activity, body weight and food intake, colon morphometry, haematological indices, oxidative and nitrosative stress markers (MPO, NO, MDA, GSH), immunological modulation through IL-10, and histopathological changes, along with HPTLC-based phytochemical standardisation.

2. Materials And Methods

2.1 Drug Preparation and Authentication

The roots of *Mimosa pudica* Linn., a traditionally recognised *Ayurvedic* herb indicated for conditions involving *Raktatisara*, *Shotha*, and *Vrana,* were sourced from a certified GMP-compliant *Ayurvedic* raw material supplier. The drug sample was authenticated by a qualified taxonomist through macroscopic and microscopic evaluation, following the standard *Ayurvedic* Pharmacopoeia of India (API) guidelines. For standardisation and phytochemical profiling, Phytochemical fingerprinting was carried out using HPTLC methodology. Methanolic extracts of the powdered roots were prepared (1 mg/mL). The mobile phase used for HPTLC was ethyl acetate: toluene: formic acid (4:5:1) with a saturation time of 15 minutes. Standard lupeol solution (200 ng/spot) and extract samples were applied to silica gel plates.

Table 1. Animal management details

Species	Albino Rats
Sex	Either Sex
Age	6-8 weeks
Initial Body Weight	140-170 grams
Source	Sciore Research Private Limited
Environmental Conditions	Room Temperature maintained between 22+30 °C: Relative humidity 50^{+}_5, illumination cycles set to 12 hours light and 12 hours dark.
Accommodation	3 rats per cage housed in the polypropylene cage with stainless steel grill top, facilities for food and water bottle, and bedding of corn cob.
Diet	Standard Pelleted Feed (Maintenance Diet)
Water	RO water

2.2 Experimental Animals and Ethical Considerations

All steps in the study were in accordance with the guidelines and regulations set forth and approved by the IEAC committee under the project proposal no.: SC/IEAC/2024/027 and the guidelines provided by the Committee for Control and Supervision of Experiments on Animals (CPCSCA) as published in the Gazette of India, December 15/1998. Prior Approval of the Institutional Animal Ethics Committee (IAEC) is in place. IAEC-17-015.

2.3 Experimental Design and Grouping

Random Division of Animals: (Randomisation)

Treatment was continued for seven days post-colitis induction. The dose selection was based on Ayurvedic human dosage extrapolated to rats using the Paget and Barnes dose conversion formula.

2.3.1 Inclusion Criteria

- Healthy rats of both sexes will be taken between 5 and 6 weeks old
- Weighing 200–250 gms

2.3.2 Exclusion Criteria

- Rats under other experiments
- Diseased rats
- Pregnant rats

2.4 Induction of Ulcerative Colitis

To replicate ulcerative colitis, acute inflammation was induced by administering TNBS rectally, a well-established chemical irritant. A solution of TNBS (50 mg/kg) in 50% ethanol was prepared freshly before use and administered intrarectally via a soft, flexible catheter (2 mm diameter), inserted 8 cm into the rectum under light ether anaesthesia. This method causes transmural

Table 2. Division of animals

Group Code	Treatment Description	n
NC (Normal Control)	Received normal saline orally without colitis induction	6
DC (Disease Control)	Received TNBS (50 mg/kg, intrarectal) in 50% ethanol	6
TG (Treatment Group)	Received TNBS + *Mimosa pudica* Linn. root extract (360 mg/kg/day, orally)	6

inflammation mimicking human ulcerative colitis in terms of pathophysiology and immune response.

2.5 Parameters Evaluated

2.5.1 Clinical Indicators

- **Body Weight:** Measured daily as an indicator of systemic health[5].
- **Food Intake:** Quantified daily per cage to assess anorexia due to colitis[6].
- **Disease Activity Index (DAI):** Disease severity was assessed using a composite score incorporating parameters such as stool form, body weight change, and gross rectal bleeding. Scores ranged from 0 to 4[7].

2.5.2 Morphometric Analysis

- Colon Weight and Length: Colon segments (cecum to rectum) were excised, cleaned with ice-cold saline, and weighed[8,9].
- Colon Weight/Length Ratio: Used to assess the extent of inflammation and oedema[10].

2.5.3 Biochemical and Immunological Markers

Tissue homogenates of colonic mucosa were prepared, and the following were estimated:

- Myeloperoxidase (MPO): A marker of neutrophil infiltration and inflammation.
- Nitric Oxide (NO): Estimated indirectly via nitrite content using Griess reagent; indicates NOS activity.
- Malondialdehyde (MDA): Marker of lipid peroxidation and oxidative stress.
- Glutathione (GSH): Endogenous antioxidant level indicating oxidative defence.
- Interleukin-10 (IL-10)[11]: Anti-inflammatory cytokine[12] evaluated using ELISA kits.
- Interleukin-10 (IL-10): An anti-inflammatory cytokine pivotal in immune tolerance and epithelial repair, is assessed to understand the immunomodulatory mechanism. An increase in IL-10 indicates suppression of pro-inflammatory cascades (e.g., TNF-α, IL-6) and restoration of mucosal homeostasis.

2.5.4 Haematological Parameters

- Haemoglobin (Hb)
- Packed Cell Volume (PCV)
- Total Leukocyte Count (TLC)
- Differential Leukocyte Count (DLC)
- Erythrocyte Sedimentation Rate (ESR)

2.6 Histopathological Evaluation

Colon tissues were fixed in 10% neutral buffered formalin, subjected to routine histological processing, and sectioned at a thickness of 5 µm. The sections were subsequently stained with Haematoxylin and Eosin (H and E) for microscopic evaluation. Histopathological scoring was performed through a semi-quantitative scale ranging from 0 to 4, based on the extent of mucosal ulceration, epithelial disruption, crypt architectural distortion, goblet cell depletion, and inflammatory cell infiltration.

2.6.1 Blinding / Masking

- Histopathological scoring was performed blinded, meaning the observer did not know which group the tissue belonged to.
- Other assessments (DAI, biochemical markers) are not explicitly stated as blinded, but the histology evaluation was.

2.7 Statistical Analysis

All quantitative results were presented as mean ± Standard Error of the Mean (SEM). Statistical comparisons among experimental groups were conducted using one-way Analysis of Variance (ANOVA), followed by Tukey's post hoc test for multiple comparisons. A p-value of less than 0.05 was considered indicative of statistical significance. Data analysis was performed using GraphPad Prism software.

3. Observations and Results

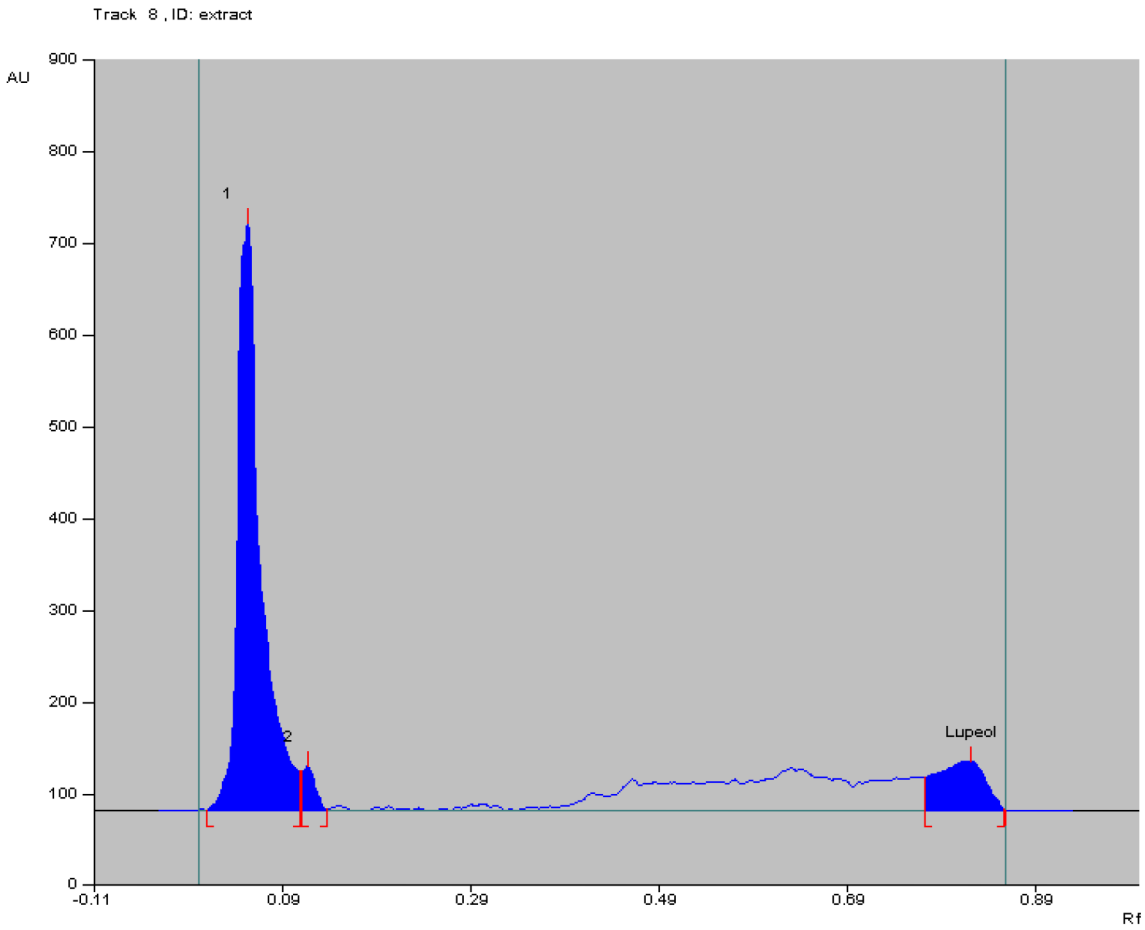
3.1 HPTLC of *Mimosa pudica*

Densitograms confirmed the presence of lupeol in the ethanolic root extract. Quantification was performed using the formula:

(Area of Sample / Area of Standard) × Concentration of Standard

For the sample:

- Sample area: 2368
- Standard area: 1176
- Standard concentration: 200 ng



Track 8, ID: extract

Peak	Start Position	Start Height	Max Position	Max Height	Max %	End Position	End Height	Area	Area %	Assigned substance
1	0.01 Rf	0.5 AU	0.05 Rf	641.1 AU	86.22 %	0.11 Rf	43.5 AU	13226.9 AU	81.86 %	unknown *
2	0.11 Rf	43.6 AU	0.12 Rf	48.3 AU	6.49 %	0.14 Rf	1.0 AU	561.5 AU	3.48 %	unknown *
3	0.77 Rf	36.0 AU	0.82 Rf	54.2 AU	7.29 %	0.86 Rf	1.6 AU	2368.8 AU	14.66 %	Lupeol

Figure 1. Densitogram of extract (10ul) 10000ng.

Thus, lupeol content:

(2368/1176) ×200=402.72 ng (2368 / 1176) \times 200 = 402.72 \, \text{ng} (2368/1176) ×200=402.72ng

It was determined that the extract contains 14.66% lupeol (from the analysis of 10 µL extract containing 10,000 ng sample). This phytochemical standardisation confirms l

upeol—a known anti-inflammatory and antioxidant triterpenoid—as a significant constituent in *M. pudica* extract, supporting its anti-colitic potential. The roots were thoroughly washed, shade-dried under hygienic conditions to preserve phytoconstituents, and ground into a coarse powder and a solution in distilled water was made for oral administration.

3.2 Disease Activity Index (DAI)

Rats in the DC group showed a significantly elevated DAI (3.8 ± 0.2) due to consistent diarrhoea, visible rectal bleeding, and progressive weight loss. The TG group receiving *M. pudica* exhibited a significantly reduced DAI (1.2 ± 0.3, $p < 0.001$), reflecting marked attenuation of clinical colitis symptoms[13].

3.3 Body Weight and Food Intake

TNBS-induced colitis resulted in a 12–15% reduction in body weight in DC animals, accompanied by a decline in food intake. *M. pudica* treatment preserved body weight and normalised feeding behaviour,

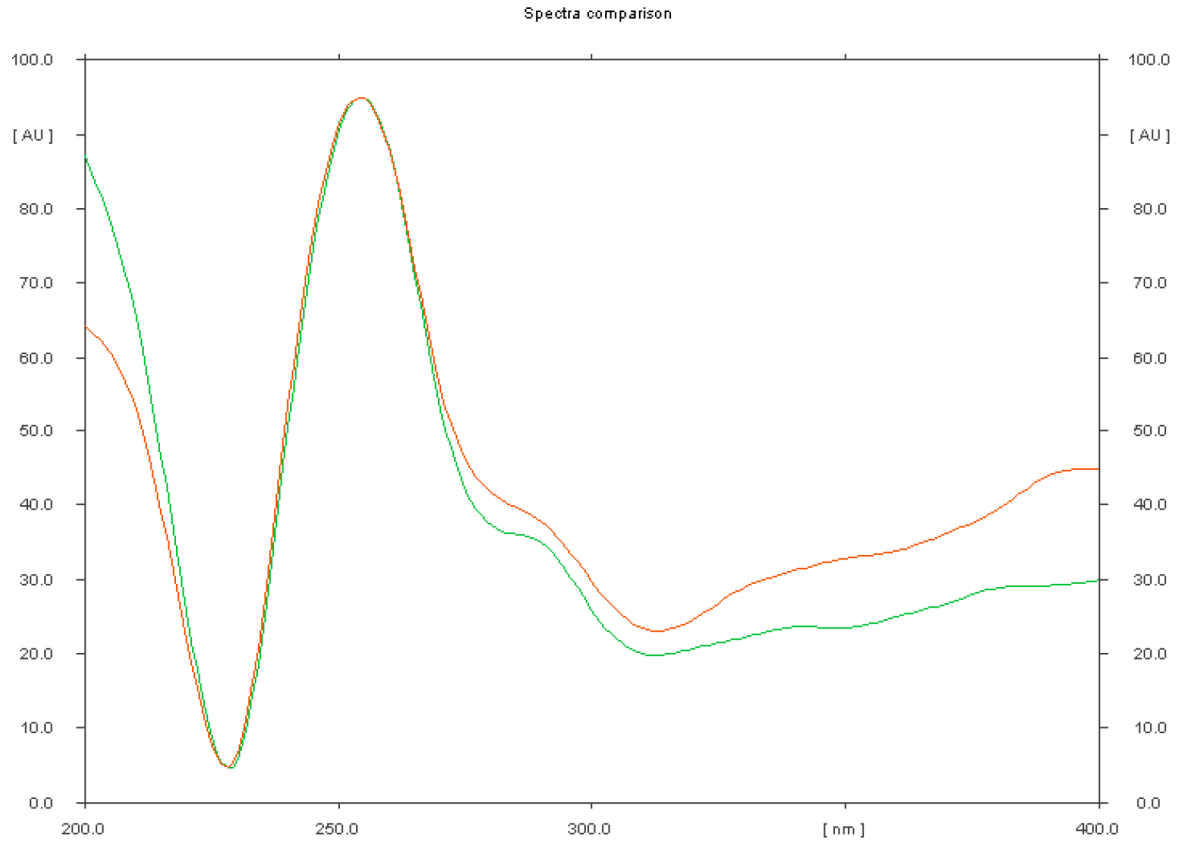


Figure 2. Overlay spectra lupeol (0.2ul) +Extract (10ul) here, green curve = *M. pudica* Linn. Extract, red curve = lupeol.

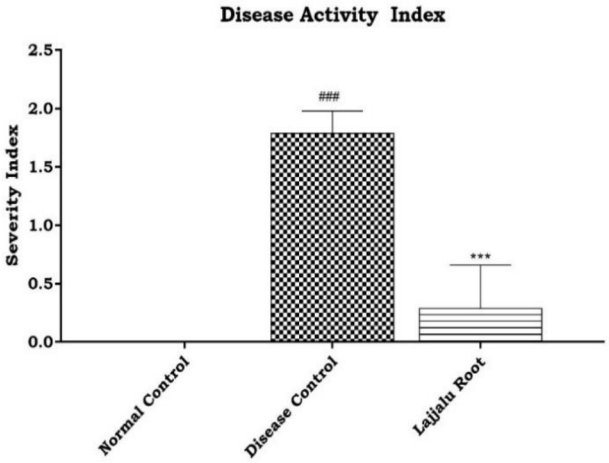


Figure 3. Disease activity index.

demonstrating systemic improvement and mitigation of colitis-associated cachexia[14,15].

3.4 Colon Morphometry

The DC group displayed significant colonic oedema and inflammation, as indicated by an increased colon weight/length ratio. In contrast, the TG group showed a significant reduction in this ratio ($p < 0.01$), suggesting resolution of inflammation and structural normalisation of the colon[16].

3.5 Histopathological Observations

Microscopic examination of the DC colonic tissue revealed severe ulceration, crypt architecture disruption, massive neutrophilic infiltration, epithelial erosion, and goblet cell loss. The TG group showed clear evidence of mucosal regeneration, epithelial restoration, reappearance of goblet cells, and minimal inflammatory infiltration[17].

Histopathological Scores (0–4 scale):

- NC: 0.2 ± 0.1
- DC: 3.6 ± 0.3
- TG: 0.8 ± 0.2 ($p < 0.001$ vs DC)

3.6 Biochemical Markers

3.6.1 IL-10

Significantly elevated in the TG group compared to DC ($p < 0.01$), suggesting enhanced anti-inflammatory

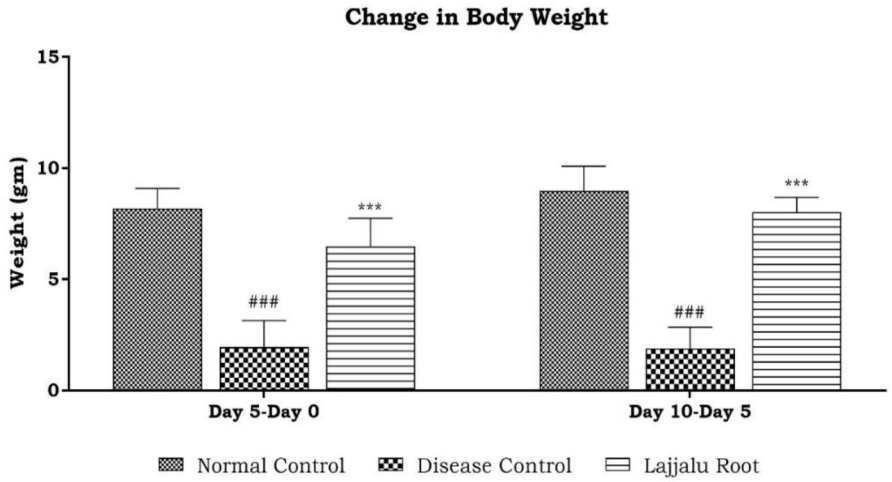


Figure 4. Change in body weight.

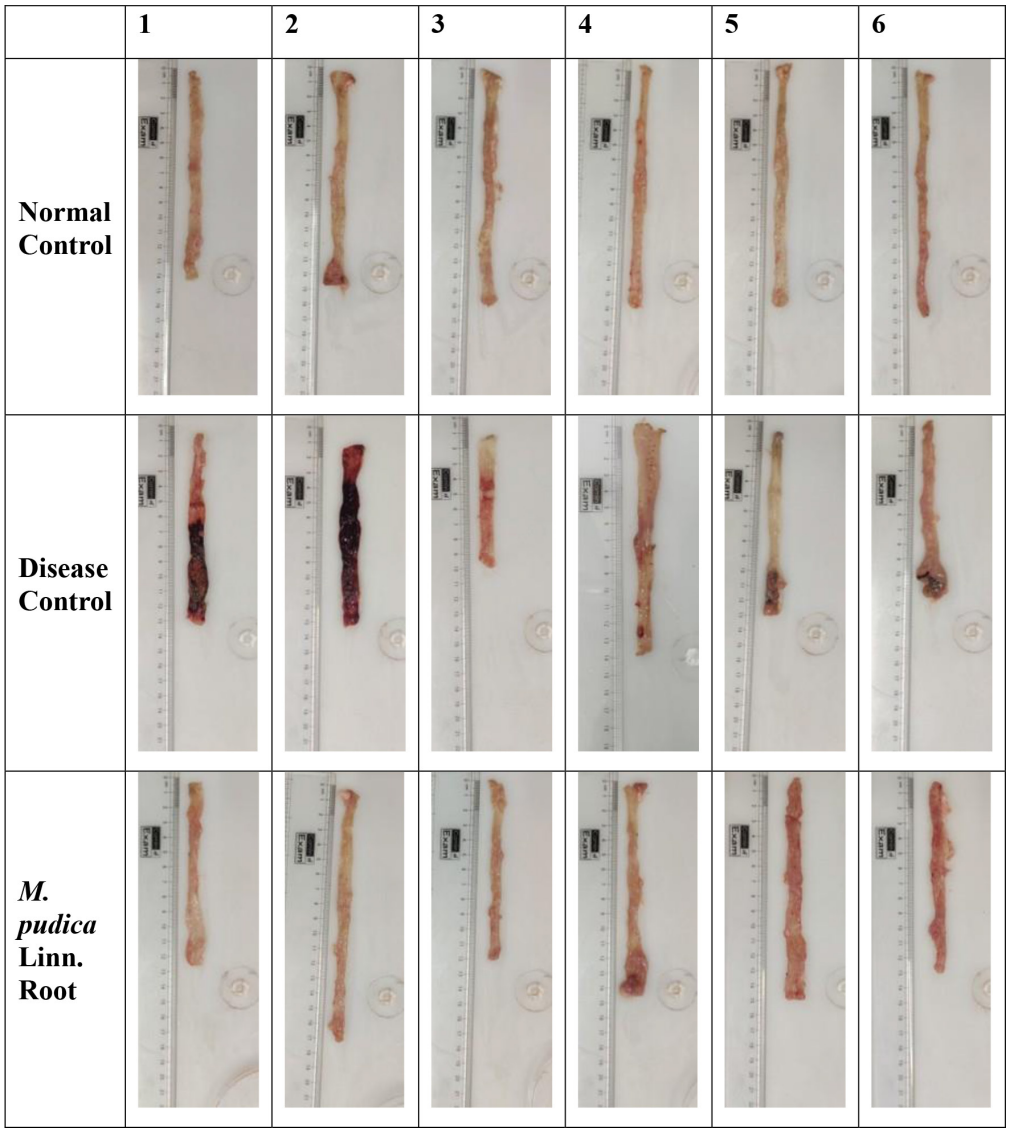


Figure 5. Anatomical changes in the colon.

cytokine response. IL-10 likely contributed to the inhibition of TNF-α, IL-6, and neutrophilic inflammation.

3.6.2 MPO

DC rats exhibited markedly elevated MPO activity, confirming intense neutrophil infiltration. MPO levels were significantly lower in the TG group ($p < 0.01$), indicating effective suppression of neutrophil-driven inflammation by *M. pudica* Linn.

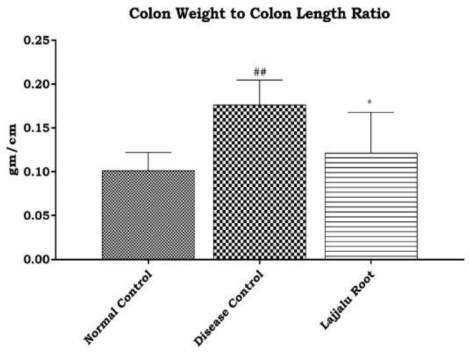


Figure 6. CW/CL ratio.

3.6.3 NO

TNBS colitis caused overproduction of nitric oxide due to iNOS activation, contributing to nitrosative stress. NO levels significantly reduced in the TG group ($p < 0.01$), suggesting downregulation of iNOS expression.

3.6.4 MDA

Lipid peroxidation was significantly elevated in the DC group, reflecting oxidative membrane damage. *M. pudica* Linn. significantly decreased MDA levels ($p < 0.01$), indicating antioxidant potential.

3.6.5 GSH

Glutathione levels were significantly depleted in DC rats due to oxidative stress. Treatment with *M. pudica* Linn.

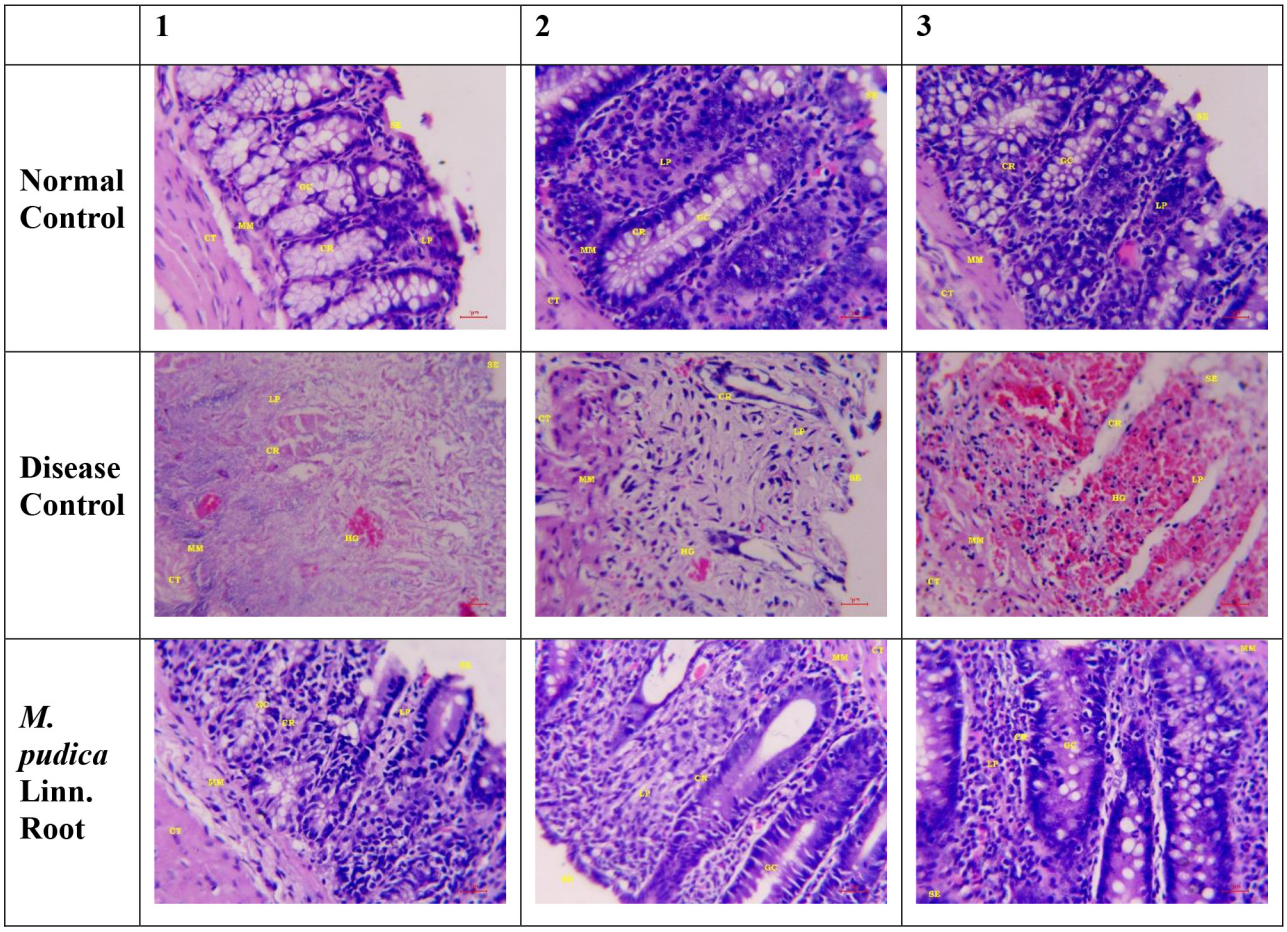


Figure 7. Histopathological changes in the colon.

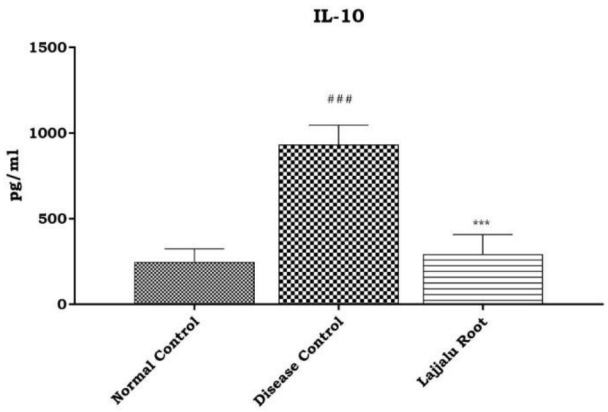


Figure 8. Difference in values of IL10 markers.

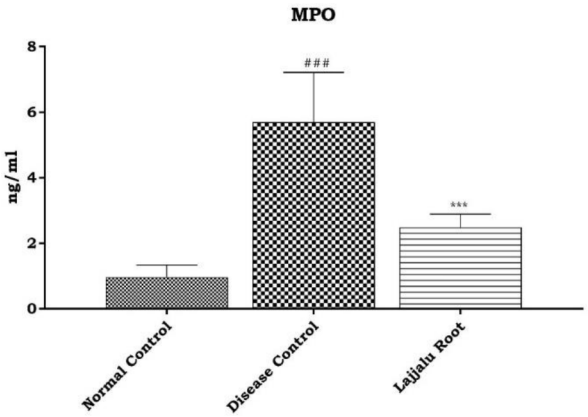


Figure 9. Difference in values of MPO levels.

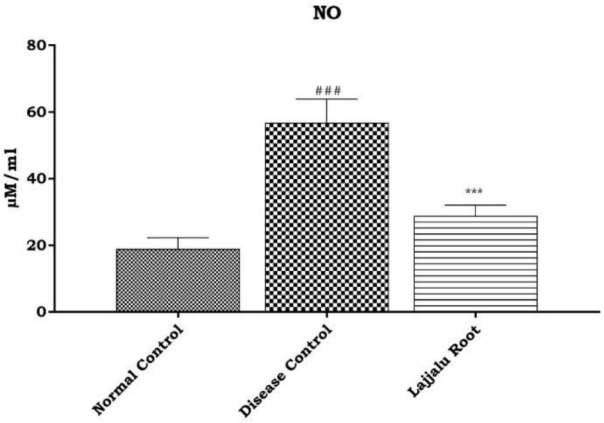


Figure 10. Difference in values of NO levels.

markedly restored GSH levels ($p < 0.001$), supporting its role in redox balance and mucosal defence[18].

3.7 Haematological Parameters

- Haemoglobin (Hb) and PCV were significantly reduced in the DC group due to blood loss and inflammation. *M. pudica* Linn. treatment restored these parameters toward normal ($p < 0.05$).
- TLC was elevated in DC rats, indicating systemic inflammation; this was normalised in the TG group.
- ESR, a non-specific inflammatory marker, was significantly elevated in DC but reduced in TG animals ($p < 0.01$), reinforcing anti-inflammatory efficacy.

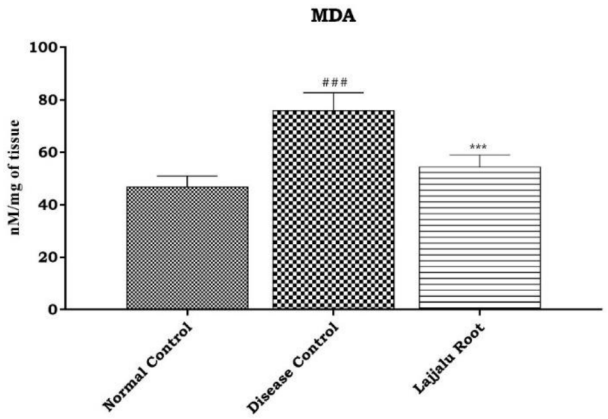


Figure 11. Difference in values of MDA levels.

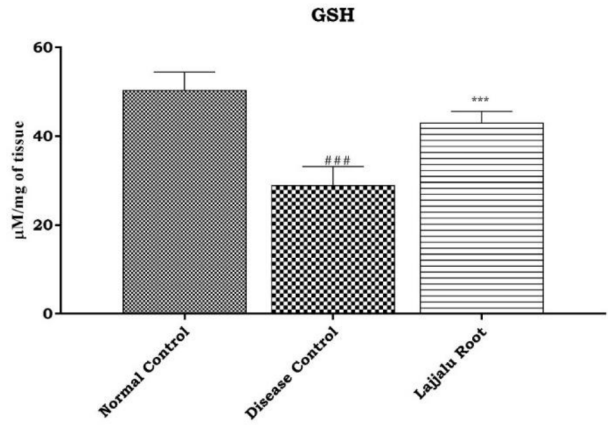


Figure 12. Difference in values of GSH levels.

4. Discussion

This *in-vivo* study demonstrates the significant therapeutic potential of *M. pudica* Linn. root powder in mitigating TNBS-induced ulcerative colitis (UC) in Wistar rats. The results validate both classical Ayurvedic claims and contemporary biomedical hypotheses through a multidimensional evaluation encompassing clinical, biochemical, immunological, haematological, and histopathological parameters.

4.1 Phytochemical Insight: Role of Lupeol

Phytochemical profiling revealed that lupeol constituted 14.66% of the *M. pudica* Linn. root extract. Lupeol is a well-recognised triterpenoid known for its anti-inflammatory, antioxidant, wound-healing, and immunomodulatory properties[19,20]. The presence of lupeol thus reinforces the anti-colitic efficacy of *M. pudica* Linn. and supports its traditional use in intestinal inflammation and wound healing[21].

4.2 Clinical Efficacy and Symptom Relief

The substantial reduction in the Disease Activity Index (DAI) indicates marked symptomatic improvement in diarrhoea, rectal bleeding, and weight loss. This aligns with *M. pudica* Linn's *Ayurvedic* attributes of absorbent (*Grahi*)and haemostatic (*Raktastambhaka*), which traditionally address excessive bowel frequency and haematochezia. Maintenance of body weight and food intake further suggests restoration of gastrointestinal homeostasis and correction of digestive hypo-function (*Agnimandya*).

4.3 Morphometric Normalisation

The decreased colon weight/length ratio in the treatment group reflects attenuation of mucosal oedema and inflammation. This morphometric restoration corresponds to the anti-inflammatory (*Shothahara*) property of *M. pudica* Linn., which in *Ayurvedic* doctrine is known to alleviate swelling (*Shotha*) and tissue congestion in the colon (*Pakwashaya*).

4.4 Oxidative Stress Modulation

UC pathogenesis involves extensive oxidative and nitrosative stress.

- Reduction in myeloperoxidase (MPO) activity confirms inhibition of neutrophil infiltration.
- Lower levels of nitric oxide (NO) and malondialdehyde (MDA) suggest suppression of iNOS-mediated inflammation and lipid peroxidation, respectively.
- Restoration of reduced glutathione (GSH) denotes reinforcement of endogenous antioxidant capacity.

These outcomes corroborate *M. pudica* Linn's classical rejuvenating (*Rasayana*) action, interpreted as enhancing tissue resilience and oxidative balance (*Dhatu Prasadana*).

4.5 Immunomodulatory Effect via IL-10

The significant increase in interleukin-10 (IL-10) highlights potent anti-inflammatory activity. IL-10 downregulates key pro-inflammatory cytokines (e.g., TNF-α, IL-6), modulates antigen-presenting cells, and promotes epithelial restitution. This suggests that *M. pudica* may influence immune signalling pathways—possibly via NF-κB suppression—promoting mucosal tolerance. *Ayurvedically*, this mirrors *Shamana* (pacification) of vitiated regulatory functional factor of the body (*dosha*)s and tissue equilibrium (*Dhatu Samyata*).

4.6 Haematological Stabilisation

Anaemia and leucocytosis, common in colitis, were significantly improved with treatment. Restoration of Haemoglobin (hb), Packed Cell Volume (PCV), Total Leucocyte Count (TLC), and ESR reflects haemostasis, reduced systemic inflammation, and improved blood integrity. These align with the blood purification and nourishment (*Raktaprasadana*) effects attributed to *M. pudica* Linn.

4.7 Histopathological Recovery

Microscopic analysis revealed near-complete mucosal regeneration, re-epithelialization, crypt preservation, goblet cell restoration, and reduced leukocytic infiltration in treated animals. This confirms structural recovery and mucosal healing, core endpoints in long-term UC management. These changes are consistent with the wound-healing (*Vrana-ropaka*) action of *M. pudica* Linn. as described in *Ayurvedic* pharmacology.

4.8 Integrative Analysis

This study validates *Mimosa pudica* Linn's traditional applications using modern scientific methods, demonstrating its multi-targeted action profile:

- Immunological: IL-10-mediated immune modulation
- Oxidative: Reduced MPO, NO, MDA; increased GSH
- Cellular: Inhibition of neutrophil activity and promotion of epithelial repair
- Systemic: Clinical improvement, haematological balance

This integrative approach affirms *M. pudica's* relevance as a complementary or adjunct therapy in UC,

offering a scientifically grounded *Ayurvedic* solution with potential translational value. Future clinical studies are warranted to evaluate its efficacy, safety, and formulation standardisation in human populations.

5. Conclusion

This *in vivo* study highlights the significant therapeutic potential of *Mimosa pudica* Linn. root powder in mitigating TNBS-induced ulcerative colitis in Wistar rats[22]. The treatment demonstrated multidimensional efficacy by improving clinical symptoms, reducing inflammatory markers, modulating oxidative stress, restoring haematological parameters, and promoting mucosal healing. Notably, the decrease in IL-10 level compared to the disease control group, Increase in GSH levels and reduction in MPO, NO, and MDA levels support its immunomodulatory and antioxidant actions. These findings scientifically validate classical *Ayurvedic* claims describing *M. pudica* Linn. as anti-inflammatory, absorbent, haemostatic, Rejuvenating, and wound healing. The integration of *Ayurveda* with modern scientific evaluation reinforces *M. pudica* Linn.'s potential as a complementary therapy for inflammatory bowel diseases like ulcerative colitis[23]. However, further research, including clinical trials, pharmacokinetic studies, and formulation development, is warranted to assess its safety, efficacy, and applicability in human populations.

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Author Contribution

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