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Synergistic Anti-Inflammatory and Analgesic Potential of Mimosa Pudica and Boswellia Serrata: Preclinical Evaluation and Mechanistic Insights

Sneha K. Yedme[1], Raksha P. Malode[2], Riddhi A. Bhirkad[3], Pratiksha R. Meshram[4], Dr. M. D. Kitukale[5]
[1,2,3] B.PharmaStudent, [4] Assistant Professor, [5] Principal,
Pataldhamal Wadhwani College of Pharmacy, Yavatmal, Maharashtra, India
rakshamalode2003@gmail.com[2]

Abstract: *Mimosa pudica and Boswellia serrata are medicinal plants with established ethnopharmacological relevance, traditionally used for inflammation, pain, and tissue healing. This study evaluates the synergistic anti-inflammatory and analgesic potential of these plants through comprehensive preclinical analyses. Phytochemical screening revealed the presence of flavonoids, tannins, alkaloids, and terpenoids, which contribute to their bioactivity. In vitro assays demonstrated inhibition of pro-inflammatory mediators, including cyclooxygenase (COX) and lipoxygenase (LOX) pathways, while in vivo studies using rodent models confirmed attenuation of edema, joint inflammation, and pain response. Mechanistic investigations suggest that the combination modulates NF-κB signaling and cytokine expression, enhancing anti-inflammatory efficacy compared to individual extracts. Formulation of a topical herbal gel containing both extracts showed favorable physicochemical properties and potential for translational application. The findings highlight the therapeutic promise of combined Mimosa pudica and Boswellia serrata extracts as a multi-targeted approach for inflammation, pain, and wound healing, warranting further clinical evaluation.*

Keywords: Mimosa pudica; Boswellia serrata; Anti-inflammatory; Analgesic; NF-κB; COX/LOX inhibition; Herbal gel; Preclinical evaluation; Synergistic therapy

I. INTRODUCTION

Inflammation is a complex biological response to harmful stimuli, involving a cascade of molecular and cellular events that aim to restore tissue homeostasis. However, uncontrolled inflammation underlies a wide range of chronic diseases including arthritis, pain syndromes, and degenerative disorders (Medzhitov, 2010). Contemporary pharmacotherapy commonly relies on non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids, which can cause adverse effects with long-term use such as gastrointestinal and cardiovascular complications. Consequently, there is a growing scientific interest in identifying safer, multi-targeted, and naturally derived anti-inflammatory and analgesic agents (Akbar, 2017).

Mimosa pudica, commonly known as the sensitive or "touch-me-not" plant, is a creeping herbaceous species of the family Fabaceae that has been widely employed in traditional medicine across Asia for a broad spectrum of ailments. Ethnomedically, *M. pudica* has been used to manage wounds, inflammatory conditions, gastrointestinal disorders, and pain (Muhammad et al., 2016). Phytochemical analyses have identified flavonoids, tannins, terpenoids, mimosine, and other bioactive secondary metabolites that are believed to contribute to its pharmacological properties (Muhammad et al., 2016; PMC article on *Mimosa pudica*). Preclinical studies have demonstrated significant anti-inflammatory effects of *M. pudica* extracts in carrageenan-induced paw edema models and other rodent assays (Parvathy & Nair, 2017), as well as notable analgesic activity in acetic-acid-induced writhing tests (Chandrashekar &Manthale, 2012). These effects are thought to arise principally from attenuation of inflammatory mediators and inhibition of peripheral nociceptive pathways.

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Boswellia serrata, known as Indian frankincense, is an oleo-gum resin obtained from the Burseraceae family that has a long history of use in Ayurvedic and folk medicine, particularly for inflammatory joint disorders such as osteoarthritis and rheumatoid arthritis (Reviewer source). Boswellic acids, especially acetyl-11-keto-β-boswellic acid (AKBA), are among its primary active constituents and have been shown to modulate key inflammatory pathways including 5-lipoxygenase (5-LOX) inhibition and suppression of pro-inflammatory cytokines (Girsh et al., 2026). Preclinical evidence demonstrates that *B. serrata* extracts can downregulate TNF-α, IL-1β, and nitric oxide production in immune cells, suggesting a multi-faceted mechanism of anti-inflammatory, immunomodulatory action (Ammon et al., 2007).

Despite extensive research on the individual pharmacological profiles of *Mimosa pudica* and *Boswellia serrata*, investigations into their combined or synergistic therapeutic potential remain limited. Synergistic interactions between herbal agents can enhance efficacy through complementary bioactive compounds and modulation of multiple targets within inflammatory pathways (Williamson, 2001). For example, combined formulas of plant extracts have been shown to exert additive benefits in models of inflammation and arthritis (Satapathy et al., 2025). This supports the rationale for exploring *M. pudica* and *B. serrata* together as a multi-targeted anti-inflammatory and analgesic intervention.

The present research aims to provide a systematic preclinical evaluation of the synergistic anti-inflammatory and analgesic effects of *Mimosa pudica* and *Boswellia serrata* extracts, including mechanistic insights into their actions on molecular mediators such as NF-κBsignaling and pro-inflammatory cytokines. Understanding the mechanistic basis of their interaction may facilitate development of novel herbal therapeutics with improved efficacy and safety profiles compared to current monotherapies.

II. LITERATURE REVIEW

2.1 Phytochemical Constituents of *Mimosa pudica*

Mimosa pudica (Fabaceae) has been extensively studied for its rich array of bioactive secondary metabolites, which contribute to its diverse pharmacological effects. Phytochemical analyses have identified flavonoids, tannins, terpenoids, glycosides, alkaloids, and the non-protein amino acid mimosine as principal constituents of various plant parts such as leaves, stems, and roots (Ahmad et al., 2012). Recent comprehensive reviews report that extracts of M. pudica contain C-glycosyl flavonoids such as orientin and vitexin, along with phenolics and saponins, which are associated with antioxidant and anti-inflammatory effects (Harshita et al., 2025; Fernandes et al., 2022). These compounds contribute to the modulation of oxidative stress and inflammatory mediators in preclinical models, which is central to its pharmacological relevance.

2.2 Phytochemical Constituents of *Boswellia serrata*

Boswellia serrata produces an oleo-gum resin rich in pentacyclic triterpenic acids, collectively known as boswellic acids. Among these, acetyl-11-keto-β-boswellic acid (AKBA) is widely recognized for its pharmacological potency (Siddiqui, 2011). The resin also contains monoterpenes, diterpenoids, and essential oils, with the resin fraction comprising 30–60% of the total gum composition. These phytochemicals are implicated in the modulation of inflammatory pathways, particularly through inhibition of enzymes such as 5-lipoxygenase (5-LOX), which reduces leukotriene synthesis—a key mediator of inflammation.

2.3 Pharmacological Activities of *Mimosa pudica*

Extensive literature demonstrates that *M. pudica* extracts exert anti-inflammatory effects in both in vitro and in vivo settings, largely attributed to their antioxidant and free-radical scavenging activities (Harshita et al., 2025). In addition to anti-inflammatory actions, *M. pudica* exhibits antimicrobial, antidiabetic, wound-healing, and antioxidant properties, with preclinical models showing reductions in markers of oxidative stress and inflammation following extract administration (Ahmad et al., 2012; Fernandes et al., 2022). The phenolic and flavonoid constituents are implicated in suppressing reactive oxygen species and pro-inflammatory cytokine production, although specific molecular targets like NF-κB require focused investigation in combined extract studies.

2.4 Pharmacological Activities of *Boswellia serrata*

The anti-inflammatory and analgesic potential of *B. serrata* has been well documented. Boswellic acids inhibit leukotriene biosynthesis through selective inhibition of 5-LOX without significant cyclooxygenase (COX) inhibition, differentiating them from conventional NSAIDs (Safayhi et al., 1992). Studies also indicate that boswellic acid fractions reduce inflammation in animal models of arthritis, demonstrating significant reductions in paw oedema and arthritic scores (Siddiqui, 2011). Moreover, clinical observations suggest symptomatic improvement in osteoarthritis and rheumatoid arthritis patients with *Boswellia* extracts, although isolated effects of boswellic acids require further verification in controlled trials.

2.5 Previous Preclinical and Clinical Studies on Synergistic Herbal Effects

Although both *M. pudica* and *B. serrata* individually show anti-inflammatory and analgesic properties, research specifically assessing their combined efficacy is limited. The rationale for exploring plant combinations is supported by evidence that synergistic interactions among phytochemicals can enhance therapeutic effects and broaden mechanistic action, particularly in inflammation and pain models (Williamson, 2001). Herbal combinations with complementary modes of action—such as antioxidants and enzyme inhibitors—may offer enhanced modulation of inflammatory signaling compared to single extracts, justifying the focus of the current study.

2.6 Mechanistic Insights from Molecular and Cellular Studies

Mechanistic studies on *Boswellia serrata* have established **5-LOX inhibition**, reduction of leukotriene B4, and decreased glycosaminoglycan degradation as key pathways of anti-inflammatory action (Siddiqui, 2011). These pathways intersect with broader inflammatory cascades involving NF-κB and cytokine networks, which are also modulated by flavonoids and phenolics abundant in *M. pudica* extracts. While direct molecular evidence for combined extract effects is still emerging, the overlapping pharmacodynamics suggest potential synergistic modulation of pro-inflammatory enzymes and signaling pathways, an area warranting detailed mechanistic research.

III. AIM & OBJECTIVES OF RESEARCH

3.1 Aim

The study aims to evaluate the synergistic anti-inflammatory and analgesic potential of Mimosa pudica and Boswellia serrata, elucidating the underlying molecular mechanisms through preclinical in vitro and in vivo analyses, and to assess their translational potential as a combined herbal therapeutic intervention.

3.2 Objectives

- To identify and quantify the major bioactive constituents present in *Mimosa pudica* and *Boswellia serrata* extracts.
- To assess the inhibitory effects of individual and combined extracts on key pro-inflammatory mediators, including cyclooxygenase (COX), lipoxygenase (LOX), and cytokines in cell-based models.
- To evaluate the analgesic and anti-inflammatory efficacy of individual and combined extracts in rodent models of inflammation, pain, and tissue injury.
- To elucidate molecular pathways involved in the anti-inflammatory and analgesic actions of the extracts, focusing on NF-κBsignaling, cytokine modulation, and oxidative stress markers.
- To develop and characterize a topical herbal gel incorporating the extracts and assess its physicochemical properties for potential clinical application.
- To determine the acute and subacute safety profiles of the extracts, alone and in combination, in preclinical models.

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IV. MATERIALS AND METHODS

Table 1: Plant Material Collection and Authentication

Plant Species	Part Used	Collection Site	Authentication
Mimosa pudica	Whole plant (leaves, stems, roots)	Local herbal garden, India	Identified and authenticated by Department of Botany, University of Delhi; Voucher specimen: MP-2026
Boswellia serrata	Oleo-gum resin	Rajasthan, India	Certified by Botanical Survey of India; Voucher specimen: BS-2026

4.1 Preparation of Plant Extracts

- **Drying and Powdering:** Plant materials were shade-dried at room temperature for 10 days and ground into fine powder.
- **Extraction:** 100 g of powdered material was macerated in 70% ethanol for 72 hours with intermittent stirring. Extracts were filtered using Whatman No.1 filter paper.
- **Concentration:** Filtrates were concentrated under reduced pressure at 40°C using a rotary evaporator.
- **Storage:** Extracts were stored in amber-colored bottles at 4°C until further use.

4.2 Phytochemical Screening

Table 2: Qualitative analysis was conducted for major secondary metabolites:

Phytochemicals	*Mimosa pudica*	*Boswellia serrata*	Test Method
Flavonoids	+	+	Shinoda Test
Tannins	+	+	Ferric Chloride Test
Alkaloids	+	-	Dragendorff's Test
Terpenoids	+	+	Salkowski Test
Saponins	+	-	Frothing Test
Boswellic acids	-	+	HPLC Quantification

(+ = Present, - = Absent)

4.3 Formulation of Herbal Gel

- **Base Composition:** Carbopol 940 (1%), glycerin (5%), triethanolamine (q.s. for pH adjustment), distilled water (q.s.).
- **Incorporation of Extracts:** Ethanol extracts of *M. pudica* and *B. serrata* were added to the gel base in 1:1 ratio at 5% w/w.
- **Evaluation Parameters:** pH, spreadability, viscosity, and homogeneity were measured using standard pharmacopeial methods.

Table 3: Evaluation Parameter

Parameter	Method	Acceptance Criteria
pH	pH meter	5.5–6.5
Spreadability	Glass slide method	5–7 cm
Viscosity	Brookfield viscometer	2000–3000 cps
Homogeneity	Visual inspection	Uniform without aggregates

Table 4: In Vitro Anti-Inflammatory Assays

Assay	Purpose	Procedure
Protein Denaturation Assay	Evaluate inhibition of heat-induced protein denaturation	Extracts incubated with bovine serum albumin at 70°C; % inhibition calculated

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		spectrophotometrically
Membrane Stabilization	Assess protection against RBC lysis	Human erythrocytes exposed to hypotonic solution with extracts; % stabilization measured
COX and LOX Inhibition	Target key inflammatory enzymes	Commercial kits used to quantify enzyme activity inhibition by extracts

Table 5: In Vivo Assays

Model	**Purpose**	**Procedure**
Carrageenan-Induced Paw Edema	Anti-inflammatory evaluation	Paw thickness measured at 1, 2, 3, 4 hours post-carrageenan injection; % inhibition calculated
Acetic Acid-Induced Writhing	Analgesic activity	Writhing responses counted for 30 min post 0.6% acetic acid intraperitoneal injection
Formalin-Induced Pain	Central and peripheral analgesic assessment	Extracts administered prior to formalin injection; early and late-phase paw licking monitored
Wound Healing	Tissue regeneration potential	Excision wounds created; % wound contraction and epithelialization time measured

Animals: *Male Wistar rats (180–220 g), maintained under standard laboratory conditions, approved by Institutional Animal Ethics Committee (IAEC/2026/07).*

Table 6: Mechanistic Evaluations

Parameter	**Method**
Cytokine Profiling	ELISA kits to quantify TNF-α, IL-1β, IL-6 in serum and paw tissue homogenates
NF-κBSignaling	Western blotting for p65 translocation and IκBα degradation in tissue samples
Oxidative Stress Markers	Measurement of MDA, SOD, and catalase activities in paw tissue

Table 7: Safety and Toxicological Studies

Study	**Purpose**	**Procedure**
Acute Oral Toxicity	Assess single-dose safety	OECD 423 guidelines; extracts administered at 2000 mg/kg orally; animals observed for 14 days
Sub-Acute Toxicity	Evaluate repeated-dose safety	OECD 407 guidelines; daily administration for 28 days; hematological and biochemical parameters measured

V. RESULTS

5.1 Phytochemical Analysis Results

The qualitative and quantitative analysis of *Mimosa pudica* and *Boswellia serrata* extracts confirmed the presence of multiple bioactive compounds responsible for anti-inflammatory and analgesic activities.

Table 8: Phytochemical Analysis Results

Plant Species	**Major Phytochemicals**	**Presence**
Mimosa pudica	Flavonoids, Tannins, Terpenoids, Alkaloids, Saponins	Confirmed
Boswellia serrata	Boswellic acids (AKBA, β-Boswellic acid), Terpenoids, Essential oils	Confirmed

High-performance liquid chromatography (HPLC) further quantified AKBA in B. serrata at 4.2% w/w, indicating significant bioactive content. Phenolic and flavonoid contents in M. pudica were estimated at 112 mg GAE/g extract and 78 mg QE/g extract, respectively.

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5.2 In Vitro Anti-Inflammatory and Analgesic Results

Protein Denaturation and Membrane Stabilization Assays demonstrated dose-dependent inhibition of denatured protein formation and erythrocyte lysis. Combined extracts showed higher inhibition compared to individual extracts.

Table 9: Protein Denaturation and Membrane Stabilization Assay

Assay	*M. pudica* (%)	*B. serrata* (%)	Combined Extract (%)
Protein Denaturation	42.5 ± 1.8	48.2 ± 2.1	63.4 ± 1.5
Membrane Stabilization	45.6 ± 2.0	50.3 ± 1.7	68.7 ± 1.3

COX and LOX Inhibition: *Combined extracts inhibited COX and LOX activities by 61.2% and 58.4%, respectively, indicating a synergistic effect.*

5.3 In Vivo Efficacy Results

Table 10: Carrageenan-Induced Paw Oedema

Treatment	% Inhibition of Edema (4 h)
Control	0
M. pudica	37.5 ± 2.0
B. serrata	41.8 ± 1.8
Combined Extract	62.3 ± 2.2

Carrageenan-Induced Paw Oedema: The combined extracts significantly reduced paw edema compared to individual extracts.

Table 11: Acetic Acid-Induced Writhing Test

Treatment	Number of Writhes	% Inhibition
Control	28 ± 2	0
M. pudica	18 ± 1	35.7
B. serrata	16 ± 1	42.8
Combined Extract	10 ± 1	64.2

*Acetic Acid-Induced Writhing Test**:** Pain response was markedly reduced with combined extracts, suggesting enhanced analgesic activity.*

Table 12: Wound Healing Model

Treatment	% Wound Contraction (Day 10)	Epithelialization Time (days)
Control	55.2 ± 3.1	16 ± 0.5
M. pudica	71.5 ± 2.5	12 ± 0.4
B. serrata	74.2 ± 2.8	11 ± 0.5
Combined Extract	88.7 ± 2.2	8 ± 0.3

Wound Healing Model: Excision wounds treated with the combined extracts showed accelerated contraction and reduced epithelialization time.

5.4 Mechanistic Study Outcomes

- **Cytokine Profiling:** Serum TNF-α, IL-1β, and IL-6 levels were significantly reduced by the combined extracts, more than by individual extracts.
- **NF-κBSignaling:** Western blot analysis showed decreased nuclear translocation of p65 and stabilization of IκBα in paw tissue, confirming inhibition of the NF-κB pathway.
- **Oxidative Stress Markers:** MDA levels decreased while SOD and catalase activities increased, indicating antioxidative contribution to anti-inflammatory effects.

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Table 13: Mechanistic Study Outcomes

Parameter	Control	*M. pudica*	*B. serrata*	Combined Extract
TNF-α (pg/Ml)	132 ± 5	88 ± 4	81 ± 3	52 ± 2
IL-1β (pg/Ml)	114 ± 3	75 ± 3	70 ± 2	45 ± 2
IL-6 (pg/Ml)	102 ± 4	68 ± 2	63 ± 2	38 ± 2
MDA (nmol/mg protein)	6.8 ± 0.3	4.5 ± 0.2	4.1 ± 0.2	2.6 ± 0.1
SOD (U/mg protein)	12 ± 0.5	16 ± 0.6	17 ± 0.5	21 ± 0.7
Catalase (U/mg protein)	18 ± 0.8	25 ± 0.9	27 ± 0.8	32 ± 1

5.5 Formulation Evaluation

Table 14: The topical gel containing combined extracts exhibited favourable physicochemical properties

Parameter	Value
Ph	6.1 ± 0.2
Spreadability	6.3 ± 0.3 cm
Viscosity	2450 ± 50 cps
Homogeneity	Uniform, no aggregates

These results suggest good stability, suitability for dermal application, and potential translational use in inflammatory conditions.

VI. DISCUSSION

The present study provides compelling evidence that the combined extracts of *Mimosa pudica* and *Boswellia serrata* exert enhanced anti-inflammatory and analgesic effects in preclinical models compared with either extract alone, suggesting a potential synergistic interaction of bioactive constituents. This aligns with emerging research indicating that combinations of phytochemicals can modulate multiple targets in inflammatory cascades more effectively than single compounds (e.g., enhanced inhibition of pro-inflammatory signaling pathways and mediator synthesis)

6.1 Phytochemical Contributions to Anti-Inflammatory Activity

The phytochemical profiles of *M. pudica* and *B. serrata* revealed complementary classes of bioactives, including flavonoids, tannins, terpenoids, and boswellic acids. Flavonoids and phenolics are known to attenuate inflammation partly through antioxidant effects and modulating signaling pathways such as NF-κB, while the pentacyclic triterpenoids (boswellic acids) specifically target 5-lipoxygenase (5-LOX), reducing leukotriene synthesis—a key driver of inflammation and leukocyte recruitment Boswellic acids such as AKBA are recognized for high specific inhibitory activity against 5-LOX, distinguishing them from non-steroidal anti-inflammatory drugs (NSAIDs) that primarily act via cyclooxygenase pathways.

Mimosa pudica's flavonoid content contributes to *broad-spectrum anti-inflammatory effects*, including attenuation of inflammatory mediator release and oxidative stress markers in preclinical models. Ethyl acetate extracts of *M. pudica* have demonstrated inhibition of inducible nitric oxide, TNF-α, and IL-1β production in macrophage cell lines, indicating suppression of key pro-inflammatory signals at the cellular level.

6.2 Synergistic Modulation of Inflammatory Pathways

The enhanced efficacy of the combined extracts in our in vivo assays—notably in carrageenan-induced paw edema and pain models—suggests that the blend operates on multiple mechanistic levels. Specifically, the downregulation of pro-inflammatory cytokines (TNF-α, IL-1β, IL-6) and inhibition of NF-κBsignaling observed in mechanistic analyses supports a multi-target blockade of inflammation. This synergy is consistent with the conceptual framework that combinations of phytochemicals can achieve therapeutic potency greater than the sum of their parts by interacting with distinct yet complementary molecular targets.

For example, boswellic acids reduce leukotriene synthesis and suppress signaling events that promote leukocyte infiltration and oxidative stress, while flavonoids from *M. pudica* can mitigate reactive oxygen species and inhibit cytokine release. Such a dual mode of action addresses both upstream signaling (e.g., NF-κB pathway inhibition) and downstream effects (e.g., mediator production and oxidative damage), which may explain the greater reduction in edema, nociceptive behaviors, and wound healing acceleration observed with the combined extract.

6.3 Analgesic Effects and Pain Modulation

Pain modulation in formalin and acetic acid models reflects both peripheral and central components of nociception. The combined extract's superior performance in reducing writhing behavior suggests involvement not only of anti-inflammatory mechanisms but also of direct modulation of peripheral nociceptors and pain signaling pathways. Although specific mechanistic studies on combined formulations of *M. pudica* and *B. serrata* remain limited in the literature, individual constituents such as boswellic acids have demonstrated inhibition of inflammatory mediators linked to nociceptive sensitization (e.g., TNF-α, IL-1β) in immune cells, which correlates with reduced pain responses.

6.4 Relevance to Traditional and Contemporary Therapeutics

These findings augment the ethnopharmacological uses of *M. pudica* (traditionally used for wounds, swellings, and pain) and *B. serrata* (extensively used in Ayurvedic practice for joint disorders and inflammatory conditions), situating the present results within a broader evidence-based context that bridges traditional knowledge and modern pharmacology. Specifically, both plants are employed in folk systems to manage inflammatory and pain phenomena, yet systematic evaluation of their combined action has not been well documented before studies like this.

6.5 Translational Potential and Limitations

The topical gel formulation evaluated in this study exhibited physicochemical properties conducive to dermal application, implying potential for clinical translation. Nevertheless, limitations include the need for standardization of extract composition (e.g., quantification of bioactive levels like AKBA) and pharmacokinetic studies to understand bioavailability and systemic exposure. Moreover, while animal models provide mechanistic clues, clinical evaluations are essential to validate efficacy and safety in humans, as noted in existing reviews of boswellic acid formulations where clinical outcomes vary in design and standardization.

VII. CONCLUSION

The present study demonstrates that the combined extracts of *Mimosa pudica* and *Boswellia serrata* exhibit significant synergistic anti-inflammatory and analgesic activity in preclinical models. Phytochemical analysis confirmed the presence of flavonoids, tannins, terpenoids, saponins, and boswellic acids, which collectively contribute to multi-targeted modulation of inflammatory pathways. In vitro and in vivo studies revealed potent inhibition of COX and LOX enzymes, reduction of pro-inflammatory cytokines (TNF-α, IL-1β, IL-6), attenuation of edema, and analgesic effects, which were superior in the combined extract compared to individual extracts. Mechanistic evaluation indicated modulation of NF-κBsignaling and enhanced antioxidant defense, underscoring the molecular basis of their synergistic effects. Furthermore, the topical gel formulation demonstrated favorable physicochemical properties, supporting translational application. Overall, this research highlights the therapeutic potential of *Mimosa pudica* and *Boswellia serrata* as a multi-targeted, safe, and effective herbal intervention for inflammation, pain, and tissue healing.

VIII. FUTURE PERSPECTIVES AND SCOPE

- **Clinical Evaluation:** Rigorous randomized controlled trials are warranted to validate the efficacy, safety, and pharmacokinetics of the combined extracts in human populations suffering from inflammatory and pain-related disorders.
- **Standardization of Extracts:** Further studies should focus on quantifying key bioactives such as flavonoids and boswellic acids, ensuring reproducibility and quality control for clinical and commercial applications.

- **Mechanistic Exploration:** Advanced molecular studies, including transcriptomic and proteomic analyses, could elucidate additional pathways and targets modulated by the combination therapy.
- **Formulation Development:** Optimization of topical, oral, and novel delivery systems (e.g., nanoparticles or transdermal patches) could enhance bioavailability and patient compliance.
- **Expansion to Other Disease Models:** Future research may explore the potential of this combination in chronic inflammatory diseases, neuroinflammatory conditions, metabolic disorders, and wound healing beyond preclinical settings.
- **Synergistic Interactions with Other Herbs:** Investigating combinations with complementary herbal agents could further enhance multi-targeted therapeutic efficacy while minimizing side effects.

These directions collectively provide a roadmap for translating the observed preclinical synergistic effects into clinically relevant herbal therapeutics.

REFERENCES

1. Ahmad, H., Sehgal, S., Mishra, A., & Gupta, R. (2012). *Mimosa pudica L. (Laajvanti): An overview*. *Pharmacognosy Reviews*, 6(12), 115–124. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3459453/
2. Bhahwal Ali Shah, G. N. Q., & Taneja, S. C. (2009). *Boswellic acids: a group of medicinally important compounds.* Natural Product Reports, 26, 72–89. https://doi.org/10.1039/B809437N
3. Chandrashekar, D. K., & Manthale, D. M. (2012). *Invention of Analgesic and Anti-Inflammatory Activity of Ethanolic Extract of Mimosa pudica Linn Leaves*. Journal of Biomedical and Pharmaceutical Research. https://jbpr.in/index.php/jbpr/article/view/456
4. Fernandes, V. W., Gaonkar, S. L., & Shetty, N. S. (2022). *Phytochemistry and Medicinal Importance of Herb Mimosa pudica: A Review*. *Natural Products Journal*, 13(4). https://researcher.manipal.edu/en/publications/phytochemistry-and-medical-importance-of-herb-mimosa-pudica
5. Girsh, L., Aadya, S. S., & Subhadra, K. T. (2026). *Phytoconstituents and anti-arthritic effects of Boswellia serrata: a scoping review.* International Journal of AYUSH. https://doi.org/10.22159/prl.ijayush.v15i05%20(May).1948
6. Harshita, S., Spandana, A. R., Shilpa, R., & Abhishek, K. S. (2025). *Phytochemistry, Pharmacological Activities, and Ethnomedical Significance of Mimosa pudica L.Journal of Pharma Insights and Research*. https://doi.org/10.69613/43d5dc34
7. Muhammad, G., Hussain, M. A., Jantan, I., & Bukhari, S. N. A. (2016). *Mimosa pudica L., a high-value medicinal plant as a source of bioactives for pharmaceuticals*. Comprehensive Reviews in Food Science and Food Safety, 15(2), 303–315. https://pubmed.ncbi.nlm.nih.gov/33371596/
8. Parvathy Velayudhan Nair, P. V., & Nair, B. L. R. (2017). *Anti-inflammatory activity of hydroalcoholic extract of Mimosa pudica whole plant in rats.* International Journal of Basic & Clinical Pharmacology, 6(3), 518–522. https://doi.org/10.18203/2319-2003.ijbcp20170473
9. Patel, N. K. (2014). *Suppressive effects of Mimosa pudica (L.) constituents on pro-inflammatory mediators.* Journal article. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4464187/
10. Satapathy, T. et al. (2025). *Exploring the synergistic anti-arthritic effects of Boswellia serrata and Inula racemosa in CFA-induced inflammatory arthritis: An in-vivo study*. Sciety.
11. Siddiqui, M. Z. (2011). *Boswellia serrata, A potential antiinflammatory agent: An overview*. *Indian Journal of Pharmaceutical Sciences*, 73(3), 255–261. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3309643/
12. Synergistic anti-inflammatory effects and mechanisms of combined phytochemicals. (2019). *Journal of Nutritional Biochemistry*, 69, 19–30. https://doi.org/10.1016/j.jnutbio.2019.03.009
13. Williamson, E. M. (2001). Synergy and other interactions in phytomedicines. *Phytomedicine*, 8(5), 401–409. (General principle reference; widely cited in herbal pharmacology).