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Lawsonia inermis: A Promising Natural Agent for Anti-inflammatory and Therapeutic Applications

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Abstract
Lawsonia inermis, or henna plant, has thousands of years of usage in traditional medicine for its antibacterial, antifungal, antioxidant, anticancer, immunomodulatory, and anti-inflammatory effects. This review aims to comprehensively evaluate this plant's anti-inflammatory properties and potential therapeutic applications by literature studies from scientific databases such as PubMed, Scopus, and Springer, focusing on the impact of bioactive substances on inflammation. The main active compounds, including lawsone, alkaloids, flavonoids, and tannins, were shown to inhibit pro-inflammatory mediators such as cytokines and enzymes, effectively reduce edema, accelerate wound healing, and manage both acute and chronic inflammation in vivo and in vitro studies. Clinical results have indicated promise in treating pain, wound healing, inflammatory symptom reduction, and contact dermatitis. These findings highlight the significant potential of *L. inermis* as a natural anti-inflammatory agent. However, further research is necessary to optimize its therapeutic applications, assess potential interactions with other drugs, and identify the most effective dose and route of administration.
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Keywords: Anti-inflammatory, Henna leaf, Inflammation, *Lawsonia inermis*

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Lawsonia inermis: Agen Alami yang Menjanjikan sebagai Anti-inflamasi dan Terapi

Abstrak
Lawsonia inermis, atau tanaman pacar, telah digunakan selama ribuan tahun dalam pengobatan tradisional karena khasiatnya sebagai antibakteri, antijamur, antioksidan, antikanker, imunomodulator, dan antiinflamasi. Ulasan ini bertujuan untuk mengevaluasi secara komprehensif efek anti-inflamasi dan potensi aplikasi terapeutik tanaman ini dengan studi literatur dari database ilmiah seperti PubMed, Scopus, dan Springer, dengan fokus pada senyawa bioaktif dan efeknya terhadap peradangan. Senyawa aktif utama, termasuk lawsone, alkaloid, flavonoid, dan tanin, terbukti menghambat mediator pro-inflamasi seperti sitokin dan enzim, serta efektif untuk mengurangi edema, mempercepat penyembuhan luka, dan juga menangani peradangan akut maupun kronis dalam studi in vivo dan in vitro. Hasil uji klinis juga menunjukkan potensi dalam pengobatan dermatitis kontak, penyembuhan luka, pengurangan gejala inflamasi, dan manajemen nyeri. Hal ini mendukung potensi besar L. inermis sebagai agen antiinflamasi alami. Penelitian lebih lanjut tetap diperlukan untuk mengoptimalkan aplikasi terapeutiknya, mengevaluasi potensi interaksi dengan obat lain, serta menentukan dosis dan rute pemberian yang paling efektif.

Kata Kunci: Anti-inflamasi, Daun pacar, Inflamasi, *Lawsonia inermis*

1. Introduction

The inflammatory system in our body is a defense response to harmful stimuli, including tissue injury and allergies. It typically happens when pathogenic microorganisms, including viruses, bacteria, or fungi, enter the body, settle in certain tissues, or enter the bloodstream. The process can also be triggered by ischemia, degeneration, cancer, tissue damage, or cell death.[1] The adaptive and innate immune systems play a role in the development of inflammation. Various cells, including macrophages, dendritic, and mast cells, protect the innate immune system against invasive microorganisms and cancer cells.[2] A key role is played by specialized cells, like B and T cells, in the adaptive immune system, which produce specific receptors and antibodies to eliminate invading pathogens and cancer cells.[3]

Several therapies are currently available to regulate and reduce inflammatory crises. These include steroids, nonsteroidal anti-inflammatory drugs (NSAIDs) agents, and immunosuppressants. However, it is important to note that these medications can have adverse effects. To reduce these side effects, we use the lowest effective dose that maximizes efficacy.[4] One way to achieve this is by incorporating natural anti-inflammatory elements into pharmaceutical therapy. Natural products—especially medicinal plants—are essential to this process because they have special anti-inflammatory qualities that can improve and supplement conventional therapies while possibly lowering negative side effects. These plants frequently have bioactive substances that affect inflammatory pathways, offering a complement or natural substitute for pharmaceutical medications. This way, the pharmacological response can be enhanced, and undesirable side effects can be minimized.[5]

Herbal therapy, widely adopted by traditional medical practitioners, offers valuable insights into the potential uses of Various underexplored therapeutic plants. This opens new possibilities for discovering novel drugs.[6] In folk medicine practices, the utilization of plants with medicinal properties plays a necessary part in meeting every basic healthcare demand for many developing countries. Recent reports indicate a growing interest among scientists worldwide in exploring the pharmacological activities of medicinal plants and validating Ayurveda's claims regarding their efficacy.

The henna plant, or *Lawsonia inermis* Linn, belongs to the Lythraceae family and flourishes to a height of 2 to 6 meters. It is indigenous to India, North Africa, and the Middle East. Used in Asia and North Africa, henna has grown in sunny areas for thousands of years as an ingredient in perfuming and red dye. Henna is also known to have medicinal properties and has been used worldwide for its antibacterial, antifungal, antioxidant, and immunomodulatory effects.[7] Additionally, it has analgesic, anti-inflammatory, antipyretic, and hepatoprotective properties. In addition, henna has cytotoxic properties. The plant's ability to kill bacteria and fungi is attributed to its tanning effect. It's crucial to remember that henna doesn't cause allergies or cancer.[8] *Lawsonia inermis* contains carbs, phenolic substances, saponins, flavonoids, amino acids, alkaloid compounds, terpenoids, quinones, coumarins, xanthones, fatty acids, resin, and tannins, based on phytochemical investigation.[9] Moreover, 2-hydroxy-1,4-naphthoquinone (lawsone) is present. Due to its rich chemical content, henna has been used therapeutically to address a range of conditions such as wounds, edema, headaches, and ulcers, as well as diseases like diarrhea, jaundice, leprosy, bronchitis, menstrual disorders, rheumatism, dysentery, hemorrhoids, and skin problems.[10]

Recent studies have highlighted the anti-inflammatory effects of henna and its bioactive compounds, particularly lawsone, in various experimental models. Talab et al. (2022) showed that lawsone prevented the synthesis of pro-inflammatory cytokines such as IL-6 and TNF-α in carrageenan-induced paw edema in mice. These results imply that henna could help treat inflammatory diseases.[11] Although henna has been widely studied for its diverse pharmacological characteristics, exploring its anti-inflammatory effects remains underdeveloped. This study examines the anti-inflammatory potential of henna. This research aims to deepen our understanding of the mechanisms underlying henna's anti-inflammatory activity and highlights its potential as a promising candidate for developing novel plant-based therapies for inflammatory conditions.

2. Methods

2.1. Data Sources and Search Strategy

This study hypothesizes that *Lawsonia inermis* exhibits significant anti-inflammatory activity through specific mechanisms involving its bioactive compounds. To explore this hypothesis, a comprehensive search was conducted using the keywords "*Lawsonia inermis*," "Anti-inflammatory activity," and "Henna's leaf as an anti-inflammatory." in PubMed, Elsevier, Springer, and Scopus within the last ten years, with a focus on identifying relevant studies that address the potential mechanisms of *Lawsonia inermis* in reducing inflammation. Data was gathered in July 2024 to ensure the inclusion of the most recent studies. Exclusion criteria included judgments, opinions, and irrelevant issues. The methodology's flowchart is displayed in Figure 1.

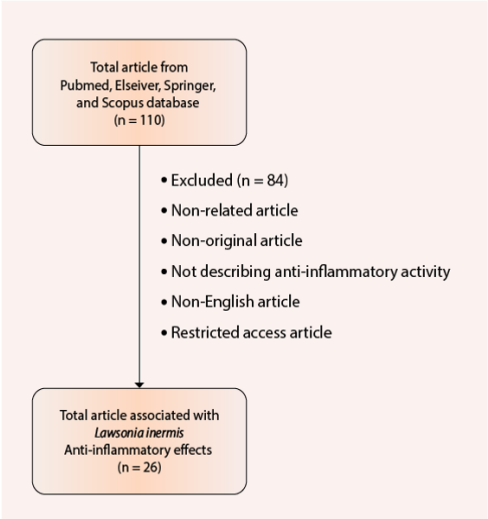

Figure 1. Flowchart of Methodology

2.2. Inclusion Criteria

To be included in this review, the literature must meet the inclusion criteria: 1) Reporting original research conducted between 2014-2024; 2) Focus on the mechanisms and receptors of *Lawsonia inermis* bioactive compounds as anti-inflammatory agents; 3) Language of the publication is English; 4) The documents were not restricted and accessible. By applying these criteria, we aim to gather a comprehensive set of in vitro and in vivo studies that directly investigate how *Lawsonia inermis* exerts its anti-inflammatory effects, thereby providing evidence to support this study.

3. Result

The review highlights key aspects of *Lawsonia inermis*'s anti-inflammatory effects. The experimental models used in the studies ranged from in vitro cell cultures to in vivo animal models and clinical trials, each with distinct dosages and administration methods. In some studies, *Lawsonia inermis* was administered via oral or intraperitoneal routes[12,13], while others used topical applications or injections.[14,15] These variations in dosage and administration were found to significantly influence the anti-inflammatory effects of *Lawsonia inermis*, with most studies showing notable reductions in markers of inflammation such as TNF-α, IL-6, and other cytokines.[13,16].

4. Discussion

The term "anti-inflammatory" describes a material or medication's ability to lessen inflammation, which is the body's complex biochemical reaction to external stimuli including infections, irritants, and damaged cells. Inflammation manifests as redness, swelling, and pain. These activities relieve pain by reducing inflammation, and blocking CNS pain signalling to the brain. Anti-inflammatory agents are important in the treatment of several conditions, including gout, migraines, osteoarthritis, and rheumatoid arthritis.[37, 38, 39] Chronic diseases are influenced by shared inflammatory pathways. Inflammatory stimuli set off intracellular signalling pathways, which in turn cause the creation of inflammatory mediators. Through interactions with TLRs, the TNF receptor (TNFR), the IL-1 receptor (IL-1R), and the IL-6 receptor (IL-6R), primary inflammatory stimuli induce inflammation. These triggers include microbial products and cytokines such as interleukin-6 (IL-6), interleukin-1β (IL-1β), and tumor necrosis factor-α (TNF-α). Receptor activation initiates pathways like Janus kinase (JAK), mitogen-activated protein kinase (MAPK), nuclear factor kappa-B (NF-κB), and signal transducer and activator of transcription (STAT).[40, 41]

The primary red pigment in henna is called lawsone (2-hydroxy-1,4-naphthoquinone). The additional components of the *L.inermis* leaf extract include Alkaloids, coumarin, glucosides, xanthones, triterpenoids, phenolics, fatty acids, quinones, phenylpropanoids, tannins, and flavonoids.[42,43] Numerous researches have demonstrated the anti-inflammatory activity of lawsone and henna. Additionally, luteolin, a flavonoid found in henna, has anti-inflammatory and anti-oxidant qualities.[44] Many methods and experimental models have been used to prove the activity of henna on inflammation as shown in Table 1.

This review integrates molecular insights with experimental and clinical findings to demonstrate the therapeutic potential of *Lawsonia inermis* in modulating inflammatory pathways and reducing oxidative stress. It focuses on the specific anti-inflammatory mechanisms of henna, including its effects on TNF-α

Table 1. Effect *L. intermis* as anti-inflamatory agents

	Experimental model	Dosage and Administration	Effects	Ref.
		IN VIVO		
1	Croton oil induced hemorrhoidal rats models	L. inermis ethanolic leaf extract at varying concentrations of 200 mg/kg/ir and 400 mg/kg/ir)	↓TNF-α (Tumor necro alpha) ↓ IL-6 (Interleukin), and.↓plasma neutrophils	12
2	Infected wound in mice models was induced by surgical procedures	L. inermis conc 0.01;0.02;0.004;0.00725 mg/mL	↓Interleukin 6 (IL-6) and interferon-alpha (TNF-α)	13
3	Rats with chronic constriction injury (CCI) experience neuropathic pain.	Intraperitoneal administration of Gabapentin (100 mg/kg) and L. inermis extract (250 and 500 mg/kg) was performed	↓ TNF-α, ↓ Thiol, ↑Malondialdehyde (MDA), ↓ IL1-β in the spinal cord of CCI rat	17
4	Experimental model of rats with second-degree burn wound	Neat gelatin-oxidized starch-henn (G/OST) matrix, G/OST (H30) nano-fibrous mat, and gauze (as the control group) were administered to each group.	↓ Macrophage counts and the inflammatory response.	18
5	Rats are used to imitate persistent pain in knee osteoarthritis caused by intra-articular injection of mono sodium iodoacetate (MIA).	Suspended of dry extract was mixed in water (0.2 g/0.3 ml)	↓ Inflammatory response measuring paw volume of extract day 1 35 nm to day 21 15 nm same as diclofenac gel	16
6	Carrageenan-induces inflammatory method rats models	Peroral of doses 300 and 500 mg/kg	Demonstrated paw edema persistent inhibition (54.97% and 65.56%) at the 4-hour mark in comparison to conventional indomethacin (74.17%)	19
7	Male mice exposed to lipopolysaccharide (LPS) were assessed.	LPS injection along with Henna leaf Extract of 300 and 500 mg/kg) dosage	↓SGOT (Serum glutamic oxaloacetic Transminase) and SGPT (Serum Glutamic Pyruvic Transaminase) that henna reduces liver inflammation, improves lipid profiles and elevates liver enzyme levels.	14
8	Mice determine the-anti-inflammatory test for edema induced by the carrageenan injection	Lawsone with a dosage (80 mg/kg) and aspirin 200 mg/kg was administered	Inhibition of Hind Paw edema Lawsone: 1.20±0.10 nm Aspirin: 1.13±0.25	11
9	Carrageenan-induces inflammatory method mice models	Ointments talc L. inermis (0.5 g/daily)	↑ Wound healing by inducing M2 Phenotype. bFGF (basic fibroblast growth factor), CD206, Collagen 1A, IL-10.	20
10	Mice was used into acute the inflammatory induced with carrageenan	The diclofenac dosage (10 mg/kg + 0.1 mL (1%)) and 2% Tween 80 with Henna were produced for the experiment.	Effect for 5 hours *L. inermis*: 4.76±0.01** Standard: 4.75±0.18***	21
11	Model of circular Excisional wound was induced in surface area in rats (314 mm2)	L. inermis groups: contains 1.5, 3, and 6 g (w/w) of hydroethanolic extract of L. inermis leaves	↓ ALP- positive and Fibrocyte *L.inermis* 6% ointments 7 mm2 and prevent monocyte to macrophage differentiation	22
12	Carrageenan-induces inflammatory method rat models	Ethanolic extract of L. inermis 200mg/kg and standard indomethacin, 5 mg/kg	↓Precentage paw volume was 55.98% compared with indomethacin of 58.13%	23
13	Writhing test in mice was induced by acetic acid	Lawsonia inermis ‘s methanolic extract 200;300;400;500 mg/kg	↓Acetic acid at all concentrations statistically significant at 1% threshold level	24
14	Examine healing effect of swiss albino mice’s wound using cosmetic formulation	Aqueous henna at dose 10 % compare control 1% silver sulfadiazine	↓ Burned area with a 22.77% shrinkage percentage by ↓IL1, IL6, TNF at first day of treatment	25
15	Rats' paws were injected with formalin s/c, and the amount of paw edema was measured to assess the extract's activity using a micrometer (vernier).	Extracts in both aqueous and ethanolic forms (200 mg/kg B.W.	Rat serum TNF-α levels demonstrated a substantial (P<0.05) decrease in proinflammatory	26
16	Using a sharp scalpel on albino wistar rats, a rectangular excisional incision of 700 m2 was produced along the marking.	50 g of the powdered leaves and 100 g of petroleum jelly were combined to create a 50% ointment mixture.	Precentage wound closure L.inermis 39.81% ; control group 13.99 %	27
17	Applying a commercial Elisa testing kit and adopting the company's suggested methodology using a model of rats	Meth extract L. inermis 100 mg/kg	↓IL-1,.IL-6,.IL-12,.IL-18 and.TNF-α.	28

18	Rabbits were shaved, sterilized, and burned a defined area on the backs of anesthetized rabbits using a heated metal cylinder.	Hydrogel film 15% Lawsonia inermis	Wound closure in 15 days: L. inermis hydrogel: 96.76% Silver sulfasalazine cream: 99.54%	[29]
		IN VITRO		
19	Haemolysis caused by heat and hypotonic solution utilizing red blood cells	Various concentration of ethanol solution of plants 50, 200, 400 and 800 µg/ml and standard aspirin at 800 µg/ml	%Inhibition of haemolysis at 800 µg/ml Extract Ethanol Lawsonia 82.9±1.04 compared to aspirin 91.4±0.22	[30]
20	Cytotoxic assay for murine macrophage RAW 264.7 cell line, peripheral blood mononuclear cells (PBMCs), and human immortalized keratinocyte cells (HaCaT)	Cons. Extracts were used 0–200.µg/ml	In LPS-induced RAW 264.7 cells, the extracts significantly scavenged ABTS and DPPH radicals, lowering NO (Nitric Oxide) levels and demonstrating anti-inflammatory potential.	[31]
21	Evaluated the anti-inflammatory properties by measuring the generation of nitric oxide in different leaf extracts using the Griess test.	Fraction CHCl3 (70%)/ MeOH (30%)	%Inhibition of haemolysis at 800 µg/ml Extract Ethanol Lawsonia 82.9±1.04 compared to aspirin 91.4±0.22	[32]
22	RBC of human cell membrane method of lysis and denaturation method of albumin	Used plant extract with cons. 50, 100, and 200 µg/ml) and conventional drug as a standard (Diclofenac sodium)	In LPS-induced RAW 264.7 cells, the extracts significantly scavenged ABTS and DPPH radicals, lowering NO (Nitric Oxide) levels and demonstrating anti-inflammatory potential.	[33]
		CLINICAL TRIAL		
23	Investigated 95 individuals aged 12-70 years who had lower extremity amputations and complained of contact dermatitis and were using prosthetic limbs	Participants were instructed to cover the parts of the severed leg that came into touch with the prosthesis with henna preparation.	Skin edema, itching, perspiration, skin thinning, and pain improved in the henna group as compared to the placebo group. (p-value<0.05).	[34]
24	Conducted on double clinical trial in all the referred primiparous 160 women 18-40 years	Separated into groups with totals 40 participants: placebo, control, consume topical henna, aply topical oak of Persian ointment	Henna group result -2.58 ± 0.29 on wound healing was higher compared the control and placebo groups (-1.62 ± 0.34) (P < 0.05) in terms of REEDA score	[15]
25	Three groups of 81 individuals were randomly assigned to receive the topical henna preparation.	The Visual Analog Scale (VAS), the 36-item Short Form Health Survey (SF-36), and the Oswestry Disability Index (ODI) were utilized to assess the patients.	↑ (higher) score of VAS p= 0.004 ↑SF-36 (p 0.011) ↑ODI (0<0.001) compared to sesame oil	[35]
26	Single-arm clinical trial pilot project. Included 9 individuals with recessive dystrophic Epidermolysis bullosa (EB), ranging in age from five to thirty-two.	The patients had been instructed to treat two erosions and two areas with moderate to severe itching sensations once a day with 1% henna ointment.	↓Localized warmth, burning, sensations of itching and redness of the skin (p<0,05)	[36]

and interleukins, providing a deeper understanding of henna's therapeutic role compared to previous studies. A significant contribution of this review is its emphasis on the gaps in the current literature, particularly the insufficient exploration of henna's mechanisms of action, which limits a comprehensive understanding of its full therapeutic potential. By addressing these gaps, this study provides direction for future research to fully explore henna's therapeutic potential and its application in inflammation-related conditions. This review aims to comprehensively evaluate the anti-inflammatory properties and potential therapeutic applications of this plant to expand our knowledge of henna's role in mitigating inflammation and highlight areas for further study. The whole mechanism is illustrated in Figure 2.

Lawsonia inermis effectively reduces both acute and chronic inflammation in animal models. In a carrageenan-induced rat model, lawsone extract demonstrated better inhibition of paw edema than aspirin and diclofenac, with an effective dose range of 80–500 mg/kg.[11,14] Henna reduces pro-inflammatory mediators like TNF-α, IL-1, IL-6, and IL-10, aiding in wound healing and reducing inflammation.[13] Topical applications, such as ointments, have shown positive results in treating skin wounds and contact dermatitis in clinical trials, with no serious side effects observed.[15,36] Additionally, henna oil has been found to reduce pain and inflammation in conditions like chronic sciatica and Epidermolysis bullosa. [35]

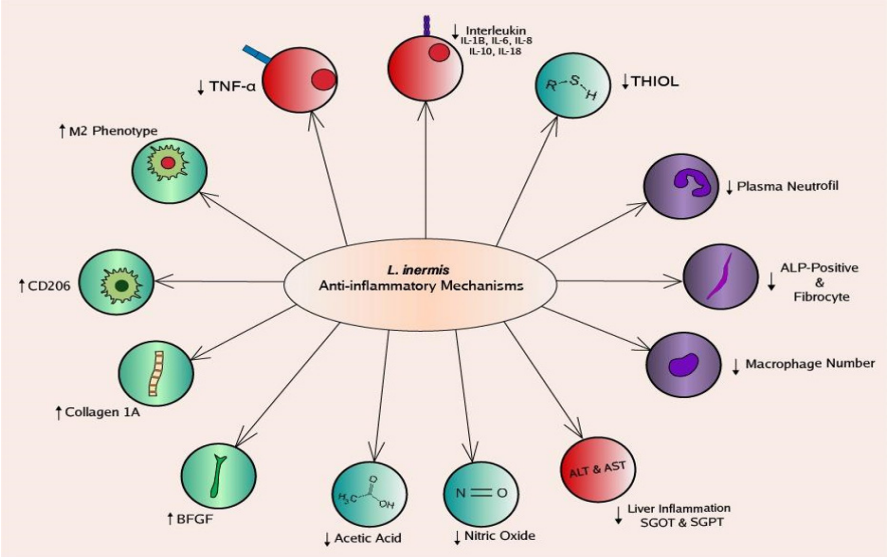

Figure 2. Summary of Henna's Leaf Anti-Inflammatory Mechanisms

Studies conducted in vivo have revealed the effectiveness of *Lawsonia inermis* in reducing acute and chronic inflammation in various animal models. In a carrageenan-induced rat model, lawsone extract exhibited better inhibition of paw edema than aspirin and diclofenac, considered standard treatments. The inhibition sustained at a rate of 65.56% and resulted in a reduction in paw volume. The effective dose of the extract to achieve this effect ranged from 80 mg/kg to 500 mg/kg.[19,11,21,23]. In studies involving inflammatory cells and animals, *L. inermis* was found to decrease the levels of pro-inflammatory mediators, including TNF-α (tumor necrosis factor-α), interleukin-1 (IL-1), IL-1β, IL-6, IL-8, IL-10, and IL-18. These effects were observed in several experimental models, including hemorrhoidal rats, mice with wound models, chronic constriction injury, and paw edema. [12,13,17,26,28] The cytokine tumor necrosis factor-alpha (TNF-α) influences various cell types in complex ways. It is recognized for its role in developing certain inflammatory and autoimmune disorders and is considered a crucial regulator of inflammatory responses. TNF-α plays a critical role in the activation and priming of neutrophils and can significantly increase their sensitivity to other inflammatory mediators.[45] Therefore, the primary function of interleukins is to regulate the processes of expansion, differentiation, and activation that occur during immunological and inflammatory responses. By attaching to high-affinity receptors on the surface of cells, interleukins—a vast class of proteins—can cause a variety of responses in tissues and cells. They perform both autocrine and paracrine functions. [46] It can be concluded that the intermediate *L. inermis* extract decreases the levels of Interleukin (IL) and TNF-α, thereby reducing inflammation and aiding in wound healing and edema reduction. In addition to the extract form, *L. inermis* has demonstrated its anti-inflammatory properties in topical preparations, such as ointments and hydrogel films. Multiple studies using rats and mice with surgically-induced skin wounds have shown that *L. inermis* ointment can reduce the response to inflammation and show wound healing by inducing the M2 phenotype. These effects were observed through increased expression of bFGF (basic fibroblast growth factor, CD206, and Collagen 1A.[20] bFGF increases the expression of endothelial adhesion molecules, which in turn potentiates leukocyte recruitment towards inflammation.[47] Collagen α1 (COL1A1) is a standard for measuring inflammation because its presence is a typical indication of oxidative stress, including reactive oxygen species (ROS).[48] Other studies measuring paw volume and wound closure have shown average improvements by day 21.[16,25,27.] Testing hydrogel films on rabbits demonstrated that wounds closed by as much as 96.76% within 15 days.[29] This is significant because the tests compared *L. inermis* preparations to standard silver sulfasalazine cream, petroleum jelly, and diclofenac gel, indicating the potential for developing henna preparations in the form of ointments. Henna nail leaves reduced SGOT and SGPT levels in liver inflammation injected with carrageenan.[14] On the other hand, it was found that plant extracts can prevent the differentiation of monocytes into macrophages, which can decrease the inflammatory phase. This may lead to an acceleration process of the wound transitioning from an inflammatory to a proliferative phase, synergistically increasing the expression of ALP, which is a cellular reaction to inflammatory stimuli through purinergic signaling.[22,18]. Acetic acid used to induce inflammation can increase mediators and activate inflammatory pathways. Then, cell writhing tests were carried out in mice, and it was found that *Lawsonia inermis*'s extract of methanol reduced acetic acid along with concentration-dependent anti-

inflammatory effects, which means that increasing the dose will reduce writhing.[24, 49]

In vitro models of anti-inflammatory activity involve cell culture techniques where enzymes and inflammatory mediator chemicals are directly exposed to *L. inermis.* Hemolysis causes the release of many red blood cell damage-associated molecular patterns (DAMPs) into circulation, potentially triggering various inflammation pathways. Lawsonia ethanol extract decreased the %inhibition of hemolysis and heat-induced hemolysis using RBCs. Another anti-inflammatory mechanism's effect on RBCs is its ability to inhibit protein denaturation by 53.75% compared to diclofenac sodium.[30, 33.] Nitric oxide (NO), an effector molecule of cellular damage, plays a significant role in mediating many aspects of the inflammatory response.[50] Typically, NO levels are measured by the Griess assay, which demonstrated that The extract significantly reduced NO levels in LPS-induced RAW 264.7 cells at 1000 µg/ml concentrations.[31, 32]

Clinical research has been conducted on human subjects primarily to assess the effectiveness of topical formulations of *L. inermis* for medicinal purposes. This randomized, double-blind, placebo-controlled clinical study investigated the efficacy of topical henna preparation in treating contact dermatitis in patients wearing lower limb prostheses. The findings showed that, two weeks after application, the henna ointment significantly improved contact dermatitis symptoms compared to the placebo group due to a reduction in inflammatory symptoms like pain, edema, itching, and sweating. Another wound healing study on episiotomy recovery was conducted using a double-blind clinical trial in the henna group for primiparous women. By day 10, henna ointment significantly reduced inflammation (0.72 ± 0.15) as measured by the REEDA score compared to the control group (1.40 ± 0.21). After 14 days, the progress in the henna group in wound healing was -2.58 ± 0.29. This value is higher compared to the placebo and control groups (-1.62 ± 0.34) ($p<0.05$).[15]

A randomized, double-blind study was also conducted on chronic sciatica. The Oswestry disability index (ODI), the 36-item short-form health survey (SF-36), and the visual analog scale (VAS) were used to evaluate 81 individuals, with the results proving that Henna oil reduced pain intensity, increased functional ability, and quality of life.[35] Skin redness, itching, burning, and localized warmth inflammatory response in Epidermolysis bullosa (EB)- were also reduced after applying 1% henna ointment.[36] No serious side effects were observed during the clinical trials of henna topical preparations. On average, significant effects became evident around the 14th day of use.

These findings align with similar studies that emphasize the anti-inflammatory properties of *L. inermis*. Its extracts have demonstrated vigorous anti-inflammatory activity, effectively reducing joint inflammation in osteoarthritic models and providing dose-dependent pain relief 28. These effects are attributed mainly to its bioactive compounds, such as lawsone and flavonoids, which exhibit potency comparable to standard anti-inflammatory drugs.51 Furthermore, while previous research primarily focused on isolated effects, our study integrates the role of *L. inermis* in modulating multiple inflammatory mediators providing a more comprehensive understanding of its mechanisms. This reinforces its potential as a therapeutic alternative while addressing gaps in the exploration of its broader pharmacological effects.

5. Conclusion

Taking all the results collectively, this review demonstrates that *Lawsonia inermis* exhibits significant anti-inflammatory properties, primarily attributed to its active compounds, such as lawsone and quercetin, which prevent the production of pro-inflammatory cytokines and enzymes. Additionally, henna's antioxidant properties contribute to reducing oxidative stress, further mitigating inflammation. While the findings support henna's potential as a natural remedy for inflammation in various conditions, the initial hypothesis that henna could serve as a valuable anti-inflammatory treatment aligns with the observed outcomes. To fully understand the underlying mechanisms and assess henna's practical applications in therapeutic settings, further research is needed, particularly on the bioavailability and optimal dosage of henna's active compounds. Overall, the current evidence suggests that henna could indeed complement existing anti-inflammatory treatments.

Conflict of Interest

The authors declare no conflicts of interest.

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