A Review on the Medicinal Herbs Used in the Treatment of Inflammatory conditions

Kadagoni Pravalika[1], Kodali Geethika reddy[2], Banothu Jhansi[3], JeripothulaVyshnavi[4], kodangal Sai kiran[5]
[1,2,3,4,5]*Department of Pharmaceutical Analysis, Marri Laxman Reddy Institute of Pharmacy, Dundigal, Hyderabad, Telangana, India-500043.*

***Abstract*—The present study is aimed at the collection and review of herbs used in the management of inflammatory conditions. Indian medicinal plants are rapidly gaining popularity for treating several acute and chronic inflammatory diseases due to their easy availability, cultural acceptance, and comparatively fewer side effects. Because of the rich biodiversity of India and the traditional knowledge preserved in Ayurveda and folk medicine, people are increasingly showing interest in plant-based remedies rather than purely synthetic medications for inflammation.**

Inflammation is a complex protective response of the body that, when persistent, contributes to disorders such as arthritis, dermatitis, inflammatory bowel disease, and metabolic and cardiovascular complications. Many Indian herbs, including Aloe vera, Curcuma longa, Zingiber officinale, Azadirachta indica,

Boswellia serrata and others, possess marked anti-inflammatory properties that are attributed to their diverse phytoconstituents like flavonoids, terpenoids, alkaloids, tannins, and phenolic compounds. These bioactive molecules modulate key inflammatory pathways by inhibiting pro- inflammatory mediators, reducing oxidative stress, and regulating immune responses, which forms the basis of their traditional and modern therapeutic use. The use of herbal medicines and practice of herbalism are expanding worldwide as more people become aware of their cost- effectiveness, accessibility, and potential health benefits in long-term inflammatory disorders.

The present review on anti-inflammatory medicinal herbs supports existing knowledge and provides a foundation for future research on standardization, mechanisms of action, clinical validation, and the wider application of these plants in various inflammation-related diseases. Further detailed investigation is still required to explore their full medicinal potential, optimize formulations, and ensure safety and efficacy in diverse patient populations.

***Index Terms*—Anti-inflammatory, Indian medicinal plants, Herbal medicine, Phytoconstituents, Chronic inflammation, Aloe vera, Curcuma longa, Zingiber officinale, Boswellia serrata, Traditional Ayurveda.**

I. INTRODUCTION

Inflammation is a fundamental protective response of the body to harmful stimuli such as infection, trauma, or chemical agents, but when this response becomes exaggerated or chronic it contributes to a wide range of diseases including arthritis, dermatitis, inflammatory bowel disease, diabetes, and cardiovascular disorders. Persistent inflammatory processes are associated with tissue destruction, pain, functional disability, and a significant reduction in quality of life, making the search for safe and effective anti-inflammatory therapies an important priority in modern medicine. Conventional anti-inflammatory drugs such as non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids are widely used, yet their long-term use is often limited by adverse effects including gastric irritation, renal damage, and immunosuppression. This has led researchers and clinicians to show renewed interest in plant-based interventions that may offer multi-target benefits with comparatively fewer side effects.

India possesses a rich heritage of traditional medicine, including Ayurveda, Siddha, Unani, and various local folk systems, which collectively describe numerous medicinal plants used in the management of inflammatory conditions. The country's diverse flora provides a vast reservoir of bioactive species such as Curcuma longa, Zingiber officinale, Azadirachta indica, Glycyrrhiza glabra, Tinospora cordifolia, and Aloe spp., many of which have been used for centuries

to treat pain, swelling, skin disorders, and systemic inflammatory complaints. In recent decades, these traditional claims have attracted scientific attention, and experimental as well as clinical studies have begun to validate their anti-inflammatory potential in various in vitro and in vivo models. As a result, Indian medicinal plants are increasingly being explored as promising leads for the development of novel anti-inflammatory agents and phytopharmaceutical formulations.

The pharmacological activity of these herbs is largely attributed to their diverse phytoconstituents, including flavonoids, terpenoids, alkaloids, tannins, phenolic acids, and saponins, which can modulate multiple molecular targets simultaneously. Studies have shown that such compounds may inhibit key enzymes like cyclooxygenase and lipoxygenase, suppress nuclear factor-kappa B (NF-κB) and mitogen-activated protein kinase (MAPK) signaling pathways, down-regulate pro-inflammatory cytokines, and reduce oxidative stress. This multi-mechanistic action is particularly valuable in chronic inflammatory disorders where complex networks of mediators are involved and single-target drugs may offer only partial relief. At the same time, many of these plant-derived agents are being evaluated for additional activities such as antioxidant, immunomodulatory, analgesic, and wound-healing effects, which may further enhance their therapeutic usefulness in inflammatory diseases.

Globally, the use of herbal medicine is expanding rapidly as patients and healthcare providers become more aware of its perceived safety, affordability, cultural acceptability, and potential to complement conventional therapies. In India, the abundance of medicinal plants, the presence of established traditional knowledge, and growing industrial interest have encouraged the integration of herbal products into various pharmaceutical, nutraceutical, and cosmeceutical preparations aimed at managing chronic inflammation. However, despite the large number of reports on individual plants, there is still a need for systematic documentation, critical evaluation of existing data, and scientific standardization of herbal formulations used for inflammatory conditions. The present review is therefore aimed at compiling available information on medicinal herbs with anti-inflammatory activity, with special emphasis on Indian plants, their phytoconstituents, mechanisms of action, and potential therapeutic applications, in order to support future research and rational clinical use.

II. TYPESOF INFLAMMATION

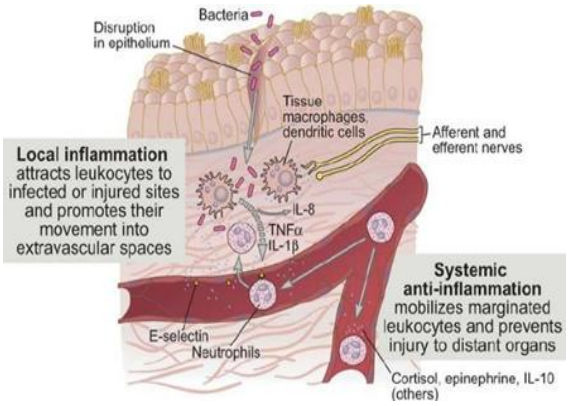
1. Based on duration

a. Acute inflammation

- Rapid onset (minutes to hours) and short duration (hours to a few days).
- Characterized by vasodilation, increased vascular permeability, and predominant neutrophil infiltration, producing the classic signs of redness, heat, swelling, pain and loss of function.
- b.subacute inflammation: Intermediate phase between acute and chronic inflammation, usually lasting about 2–6 weeks.
- Shows mixed features of acute (exudation, neutrophils) and chronic (mononuclear cells, early fibrosis and granulation tissue) inflammation.

2. Based on distribution

a. Local inflammation:Confined to a specific area or organ, such as localized skin infection or pneumonia



- b.Systemic inflammation:Generalized response with

fever,raised acute-phase proteins, leukocytosis and constitutional symptoms.

C. Chronic inflammation
Slow, long-lasting response (months to years) with mononuclear cells, tissue destruction and fibrosis

3. Morphologic patterns of acute inflammation
a. serous inflammation
Watery, protein-poor exudate, typically seen in blisters and mild injuries.

b. Fibrinous inflammation:Fibrin-rich exudate on serous surfaces like pericardium or pleura.

C. Purulent (suppurative) inflammation: Pus-forming inflammation rich in neutrophils and necrotic debris, as in abscesses

d. Hemorrhagic inflammation:
Acute inflammation where significant red blood cells leak into the exudate due to severe vascular damage

e. Ulcerative inflammation: Inflammation leading to necrosis and loss of surface epithelium, producing an ulcer that exposes underlying tissue.

f. Granulomatous inflammation:Chronic inflammation with granuloma formation, composed of activated macrophages and lymphocytes, seen in diseases like tuberculosis and sarcoidosis.

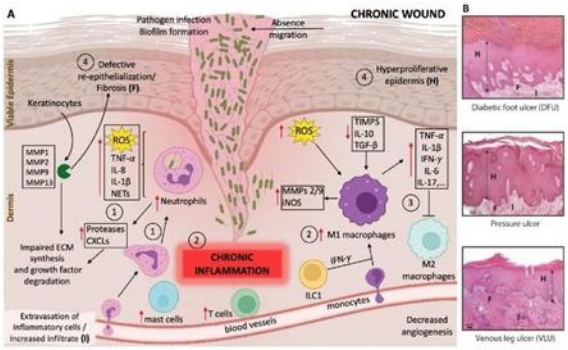
4 Based on cause (etiology)

a. Infectious inflammation: Caused by invasion of tissues by microorganisms such as bacteria, viruses, fungi, or parasites.

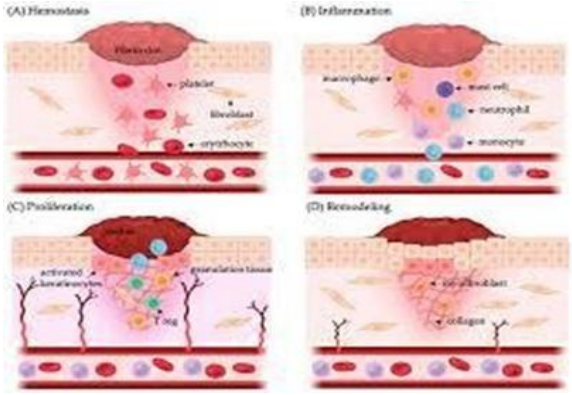
b. Immune-mediated (autoimmune) inflammation: chronic inflammation caused by a misdirected adaptive immune response in which the body's own immune system attacks self-tissues as if they were foreign, leading to progressive tissue damage.

c. Autoinflammatory inflammation: Due to the immune system mistakenly attacking the body's own tissues, as in rheumatoid arthritis, lupus, or psoriasis.

d. Allergic inflammation: Occurs when the immune system overreacts to normally harmless antigens such as pollen, food, or drugs.



d. Physical and chemical injury-induced inflammation: Physical and chemical injury-induced inflammation – inflammatory response triggered by direct tissue damage from physical agents (trauma, heat, cold, radiation) or chemical irritants/toxins (acids, alkalis, pollutants), leading to local redness, swelling, pain, and potential tissue necrosis



III. SYMPTOMS

- Common symptoms include:
- Redness at the affected area.Heat or warmth over the inflamed part.
- Swelling due to fluid build-up.

Thickened,pitted or ridged nails and swollen,stiff joints

- Pain or tenderness, especially on touch or movement.
- Loss of normal function (difficulty moving a joint, breathing, etc.).
- Possible general symptoms: fever, fatigue, and feeling unwell in some cases. and feeling unwell in some cases.a joint, breathing, etc.).

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Herbs Used In The Treatment Of Inflammation

1. Aloe Vera(Aloe barbadensis)

Aloe vera is a succulent plant whose clear inner gel is often applied on the skin or taken as juice, and many people use it to soothe swollen joints, sprains and painful knees. The gel contains natural anti-inflammatory and antioxidant substances that can calm redness, heat and swelling, so it is used for arthritis, muscle pain, burns and small skin wounds. In home practice, aloe gel may be gently rubbed over painful areas or its juice taken in small amounts to support relief from stiffness and joint discomfort.

2. Turmeric (Curcuma longa)

Curcumin is obtained from curcuma longa and belongs to the family of zingiberaceae [8].

Curcumin gel may help relieve psoriasis when combined with:

- Topical steroids
- Antibiotics and avoidance of allergens Action of curcuma against inflammation Curcuma longa (turmeric) shows

anti-inflammatory action mainly because of its yellow pigment curcumin, which is the key active compound in the rhizome. Curcumin helps block inflammatory enzymes like cyclo-oxygenase (COX-2) and lipoxygenase, so the body produces fewer inflammatory chemicals such as prostaglandins and leukotrienes. It also turns down important inflammation "switches" inside cells (for example NF-κB and MAPK pathways), which reduces the release of inflammatory cytokines like TNF-α, IL-1 and IL-6. Along with this, curcumin acts as a strong antioxidant, mopping up free radicals that otherwise keep inflammation going and damage tissues. Because of these combined actions, regular use of turmeric/curcumin can help reduce swelling, redness, pain and stiffness in many chronic inflammatory conditions such as arthritis, bowel inflammation and psoriasis

3. Neem (Azadirachta indica)

Neem leaves are obtained from the Azadirachta plant and belongs to family Meliaceae.

Neem leaves have been traditionally used in Ayurvedic medicine for various skin conditions, including psoriasis. Here are some ways neem leaves may help with psoriasis:

1. Anti-Inflammatory Properties:Neem leaves contain compounds that have anti-inflammatory effects. This can help reduce the redness and swelling associated with psoriasis.
2. Antimicrobial Effects: Neem has natural antimicrobial properties that may help prevent infections in areas of skin affected by psoriasis, which can be vulnerable to bacterial and fungal infections.
3. Immune System Regulation: Neem is believed to have immunomodulatory effects, helping to balance the immune response. This can be beneficial for psoriasis, which is an autoimmune condition. Action of neem against inflammation

Neem leaves, bark, oil and seed extracts contain natural compounds (like nimbidin and other phytochemicals) that block inflammatory enzymes such as cyclo-oxygenase (COX) and lipoxygenase (LOX), so fewer inflammatory substances are produced at the site of injury or disease. They also help switch off key inflammatory signals inside cells, including NF-κB and pro-inflammatory cytokines like

TNF-α, IL-1 and IL-6, which together reduces redness, swelling and pain. Because of these actions, neem is traditionally used for painful and swollen joints, skin problems like acne and eczema, and other chronic inflammatory complaints, either as pastes and oils applied on the skin or as herbal preparations taken by mouth.

3 Ginger (Zingiber officinale)

The main chemical constituents of ginger responsible for anti-inflammatory action are the phenolic compounds gingerols (especially 6-gingerol) and shogaols (especially 6-shogaol).

These, along with related compounds like zingerone and paradols, reduce inflammation by blocking COX and LOX enzymes and lowering inflammatory mediators such as prostaglandins, leukotrienes and cytokines.

Action of ginger against inflammation

Ginger rhizome is a common kitchen spice traditionally used to relieve pain, swelling and stiffness in joints, muscles and the digestive tract. It contains active compounds like gingerols and shogaols, which reduce inflammation by blocking inflammatory mediators (prostaglandins, leukotrienes) and lowering cytokines such as TNF-α and IL-1β, similar to mild NSAID-like action. Because of this, ginger is widely used as tea, fresh juice or powders to help in osteoarthritis, muscle soreness and other chronic inflammatory conditions

Tulasi (Holy basil, Ocimum sanctum / O. tenuiflorum)

Tulasi (Holy basil, Ocimum sanctum / O. tenuiflorum) is a sacred Indian medicinal plant whose leaves and other parts are used in Ayurveda to treat cough, colds, skin problems and many inflammatory conditions.

- Tulasi contains eugenol and other phytochemicals that reduce inflammatory chemicals in the body, giving it natural anti-inflammatory and mild pain-relieving effects.
- Fresh tulasi leaves are chewed or taken as herbal tea (decoction or infusion) to help soothe inflammation in the throat, airways and gut, such as cough, bronchitis and gastritis.
- Leaf paste or juice is applied on the skin to calm local inflammation in conditions like insect bites, mild eczema, fungal infections and itchy rashes.
- Tulasi preparations are used for joint and muscle pain, where their anti-inflammatory and antioxidant actions help reduce swelling and stiffness.
- Because tulasi also acts as an adaptogen and immunomodulator, regular use can help the body handle physical and emotional stress, indirectly lowering chronic low-grade inflammation. Related

Active compounds in tulsi that reduce inflammation

Mechanisms by which tulsi modulates inflammatory pathways

Clinical trial evidence for tulsi in inflammatory conditions

Recommended oral dose and duration of tulsi for inflammation

Possible drug interactions and side effects of tulsi supplements

Shankhapushpi (mainly Convolvulus pluricaulis or Evolvulus alsinoides)

Shankhapushpi is an Ayurvedic brain-tonic herb (mainly Convolvulus pluricaulis or Evolvulus alsinoides) that also shows cooling, shothahara (anti-inflammatory) and wound-healing actions useful in inflammatory conditions.

A traditional Medhya Rasayana herb used to improve memory, calm the mind and support the nervous system in Ayurveda.

Classical texts and modern reviews describe it as having antioxidant, anti-inflammatory, analgesic and mild antipyretic properties.

- It contains flavonoids and other phytochemicals that help combat oxidative stress and inflammation in different tissues.

How it is used in inflammation

- For general "heat" and swelling: Described as shothahara and "cooling", so it is given to reduce excess pitta-type heat and inflammatory swelling in the body.
- For skin inflammation: Used internally and as paste/wash to help in itchy, inflamed skin conditions like eczema, dermatitis, acne and other rashes due to its anti-inflammatory, antipruritic and antibacterial effects.

Licorice (Mulethi, Glycyrrhiza glabra)

Licorice (Mulethi, Glycyrrhiza glabra) is the sweet-tasting root of a leguminous plant, traditionally used in Ayurveda, Unani and Chinese medicine to soothe cough, digestive irritation and skin problems, mainly because of its strong anti-inflammatory and antioxidant effects.

- Licorice is the dried root of Glycyrrhiza glabra, containing key compounds like glycyrrhizin and glycyrrhetinic acid, plus many flavonoids.
- These constituents give licorice antiallergic, antimicrobial, anti-ulcer and marked anti-inflammatory properties, so it is added to many traditional herbal formulas.

How it is used to treat inflammation

- For stomach and intestinal inflammation: Licorice extracts and decoctions are used in gastritis, peptic ulcers and colitis to increase protective mucus, reduce inflammatory mediators and help healing of irritated mucosa.
- For joint pain and arthritis: Licorice helps in rheumatoid arthritis and other joint problems by lowering inflammatory cytokines (like TNF-α, IL-6) and prostaglandins, which reduces pain, swelling and stiffness.
- For skin inflammation: Licorice creams, gels and ointments are applied on eczema, dermatitis, acne and irritated skin because its compounds calm redness, itching and allergic inflammation.
- For throat and respiratory irritation: Traditional syrups and kadhas with licorice are used to soothe sore throat, dry cough and bronchial irritation by coating the mucosa and reducing local inflammation.

Ashwagandha (root of Withania somnifera)

Ashwagandha is a traditional Ayurvedic herb (root of Withania somnifera) used as a Rasayana to increase strength, reduce stress and calm chronic inflammation in the body

- Ashwagandha is a small shrub whose roots are used in powders, tablets and extracts, known for adaptogenic, anti-inflammatory and antioxidant effects.
- Its main active compounds are withanolides (like withaferin A) and related steroids that act on the immune and stress pathways.

How it is used to treat inflammation (simple points)

- Joint pain and arthritis: Taken as churna (powder), tablets or standardized extracts to reduce joint pain, swelling and stiffness by lowering inflammatory cytokines such as TNF-α and IL-1β.

- General body inflammation and muscle soreness: Used daily to decrease COX-2 and nitric oxide production, which helps reduce body aches and inflammatory pain after exertion or chronic illness.
- Skin and wound inflammation: Ashwagandha root extracts are applied or taken internally to calm inflamed skin and support faster wound healing by reducing NF-κB/MAPK-driven inflammatory signals.
- Stress-related inflammation: Because it reduces stress and anxiety, it also indirectly lowers stress-induced inflammatory markers and oxidative damage in organs.

Clinical trial evidence for ashwagandha in inflammatory conditions
Common ashwagandha preparations doses and administration routes for inflammation
Possible side effects and drug interactions of ashwagandha
Active compounds in ashwagandha responsible for anti-inflammatory effects

IV. NEW INNOVATION IN INFLAMMATION

1. New innovations in inflammation mainly focus on targeting specific molecules, helping the body to switch off inflammation correctly, and delivering drugs more safely and directly to the diseased area.
2. Targeted biologic drugs: New monoclonal antibodies (like canakinumab for IL-1β and experimental IL-6 blockers such as ziltivekimab) directly block key inflammatory cytokines and are being used or tested in heart disease, arthritis and other chronic inflammatory conditions.
3. Specialized pro-resolving mediators (SPMs): Recently discovered natural lipid molecules such as resolvins, protectins, maresins and lipoxins help the body actively "resolve" inflammation, stop extra white blood cell entry and promote healing rather than just blocking inflammation.
4. Nanotechnology for drug delivery: Nano-particles are being developed to carry anti-inflammatory drugs directly to inflamed tissues, allowing high local effect with lower dose and fewer side effects in conditions like brain inflammation, lung diseases and infections.
5. New targets in gut inflammation (IBD): New small-molecule and biologic therapies are being tested against pathways like PDE4, TYK2, TLRs and gut microbiome imbalance to treat Crohn's disease and ulcerative colitis more precisely and with better long-term control.
6. Anti-inflammatory therapies in heart and vessel disease: Ongoing trials are studying anti-inflammatory drugs (IL-1, IL-6 inhibitors and others) alongside standard heart medicines to reduce heart attacks and strokes by lowering chronic vascular inflammation

V. INVOVEMENT OF AI TO TREAT INFLAMATION

Artificial intelligence is mainly being used to find inflammation early, measure it more accurately, and choose better treatment for each patient, rather than directly acting like a medicine.
AI looks at large amounts of medical data (scans, lab results, biopsy slides, reports) and finds patterns of inflammation that doctors may miss or take longer to see, so treatment can start earlier and be better targeted.
Where AI is helping in inflammation

- Better diagnosis from images: In ulcerative colitis and Crohn's disease, AI systems read colonoscopy videos and endoscopy images to tell if the bowel is actively inflamed or healing, sometimes with accuracy above 90%, which can reduce unnecessary biopsies.
- Grading severity of disease: AI tools can score how severe inflammation is (for example in IBD or inflammatory skin diseases) in a more objective, consistent way than human scoring alone, helping doctors adjust medicine dose correctly.
- Personalized treatment plans: By combining data on symptoms, lab tests, genes and past response to drugs, AI models can predict which patient is more likely to benefit from a particular biologic or immunosuppressant, avoiding trial-and-error.
- Predicting flares and complications: Machine-learning models can warn about upcoming flares in chronic inflammatory diseases (like IBD or rheumatoid arthritis) by tracking trends in blood tests, stool markers, imaging and even wearable-device data.

- Helping in drug discovery: AI is used to scan huge chemical and biological databases to find new targets and molecules that may control inflammation (for example new cytokine blockers or small-molecule inhibitors) much faster than manual research alone.
- Biomarker discovery: Using gene-expression and protein data from inflamed tissues, AI helps identify new biomarkers that distinguish different inflammatory diseases or stages (for example RA vs spondyloarthritis, UC vs Crohn's).
- Linking imaging with blood markers: AI combines scan results (MRI, PET, ultrasound) with blood or stool markers to give a more complete picture of where inflammation is active and whether it is resolving with treatment

VI. CONCLUSION

Inflammation underlies a wide range of acute and chronic diseases, and Indian medicinal plants offer multi-target, comparatively safer options to modulate this response through their rich phytoconstituents. Herbs such as Aloe vera, Curcuma longa, Zingiber officinale, Azadirachta indica, tulasi, ashwagandha, shankhapushpi and licorice act via antioxidant, immunomodulatory and enzyme-inhibiting mechanisms to reduce redness, swelling, pain and tissue damage in diverse inflammatory conditions. At the same time, newer targeted drugs, delivery systems and AI-based tools are improving diagnosis and personalization of anti-inflammatory therapy, highlighting the potential of integrating traditional herbal knowledge with modern advances. Well-designed clinical trials, proper standardization and safety evaluation are still essential to translate these promising herbal and technological approaches into reliable, evidence-based treatments for inflammation.

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