



HERBAL ALLIES AGAINST INFLAMMATION: A REVIEW OF ANTI-INFLAMMATORY ACTIVITY IN MEDICINAL PLANTS

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ABSTRACT

Inflammation is a complex biological response to harmful stimuli such as pathogens, damaged cells, or irritants, playing a critical role in the pathogenesis of numerous chronic diseases including arthritis, cardiovascular disorders, and neurodegenerative conditions. While conventional anti-inflammatory drugs are effective, they often cause adverse side effects with long-term use. In recent years, increasing attention has been directed toward medicinal plants as sources of natural anti-inflammatory agents. This review highlights the pathophysiology of inflammation and explores a variety of herbal plants known for their anti-inflammatory properties, examining their bioactive constituents, mechanisms of action, and potential therapeutic applications. Emphasis is placed on bridging traditional knowledge with modern scientific evidence to support the integration of plant-based remedies into contemporary healthcare.

KEYWORDS: Anti-inflammatory activity, Medicinal plants, Herbal medicine, Phytochemicals, Natural remedies, Traditional medicine, Plant-based therapeutics.

INTRODUCTION

Inflammation is an ancient medical term initially referring to classic signs and symptoms, including edema, erythema (redness), warmth, pain, and loss of function (Stiffness and immobility).^[1] Currently, inflammation is recognized as a set of changing responses to tissue injury primarily caused by factors such as toxic chemicals, environmental agents, trauma, overuse, or infection. Some of these responses can facilitate wound healing and infection control or pathology, as in many chronic disease states.^[2] Inflammation is a second-line defence against infectious agents. The responses evoked by inflammation are a keystone of pathology. Diseases where inflammation plays a dominant pathological role have the suffix *-itis*. Both cell-mediated and humoral responses of the immune system are central to inflammation.^[3] This activity summarizes how inflammation is linked to cardiovascular disease and cancer, two global causes of mortality and morbidity.

Acute or chronic inflammation

Acute inflammation has a rapid onset of minutes or hours, typically resolves within a few days, has classic signs and symptoms, and has a cellular infiltrate

primarily consisting of neutrophils.^[4] The erythema observed in acute inflammation results from increased blood flow to the affected area due to vasodilation. Vasodilation is triggered by various mediators, with histamine as a notable example, acting on vascular smooth muscle. This process initially affects the arterioles and opens new capillary beds in the affected area.^[5] Besides blood vessels, lymphatic vessels are active in acute inflammation. In inflammation, lymph flow is increased and helps drain edema fluid that accumulates because of increased vascular permeability. Along with fluid, leukocytes, cell debris, and microbes may also enter the lymph.^[6] Similar to blood vessels, lymphatic vessels proliferate during inflammatory reactions to handle the increased load.^[7]

The acute inflammatory process is a 4-stage process that begins with the initiation phase, triggered by the injury. This phase involves changes to the microcirculation, leading to fluid loss and the migration of white blood cells to the injured area. The amplification phase follows, where chemical substances direct additional types of white blood cells to the site, enhancing the response. The rapid neutralization of the injury and debris removal characterizes the destruction phase. Finally, the

termination phase requires the action of chemical substances to halt or regulate the inflammatory process, preventing excessive damage if unchecked.^[2]

Causes

Causes of inflammation are apparently causes of diseases such as

1. **Physical agents** - Mechanical injuries, alteration in temperatures and pressure, radiation injuries.
2. **Chemical agents**- Including the increasing lists of drugs and toxins.
3. **Biologic agents** (Infectious)- bacteria, viruses, fungi, parasites
4. **Immunologic disorders**- Hypersensitivity reactions, autoimmunity, immunodeficiency states etc
5. **Genetic/Metabolic disorders**- Examples gout, diabetes mellitus etc...

Examples of diseases with specific inflammation

- Syphilis
- Tuberculosis
- Leprosy
- Glanders (Syn: Equinia, Farcy, or malleus)
- Schleroma

Inflammation symptoms

A specific part of your body might be affected, or your symptoms might be more general.

Inflammation in joints

When a joint is affected, the symptoms include:

- Redness
- A swollen joint that may be warm to the touch
- Joint pain
- Joint stiffness
- A joint that doesn't work as well as it should

Flu-like symptoms

- Fever
- Chills
- Fatigue/loss of energy
- Headaches
- Loss of appetite
- Muscle stiffness

Other symptoms

- Pain in your belly
- Rash on your skin
- Diarrhoea, constipation, or acid reflux
- Sores in your mouth
- Weight gain or loss
- Depression, Anxiety, or other mood disorders

The inflammatory phase is a normal part of the wound healing process. The capillaries inside the granulation tissue compress and a coagulation forms after the first wound. Once haemostasis has been established, After that, blood capillaries expand to permit important cells, enzymes, and white blood cells to pass through. factors, enzymes, and vitamins to get to the injured area. The function, signs, and symbols are all present at this level. and irritation symptoms such as erythema, heat, oedema, pain, and functional impairment disturbance. Through phagocytosis, neutrophils aid in the removal of contaminants from wounds., Figure 1: Timescale and stages of tissue repair. The Mechanism of Inflammatory Response:- The coordinated activation of signalling pathways that govern inflammation is known as the inflammatory response. amounts of inflammatory mediators in resident tissue cells and recruited inflammatory cells.

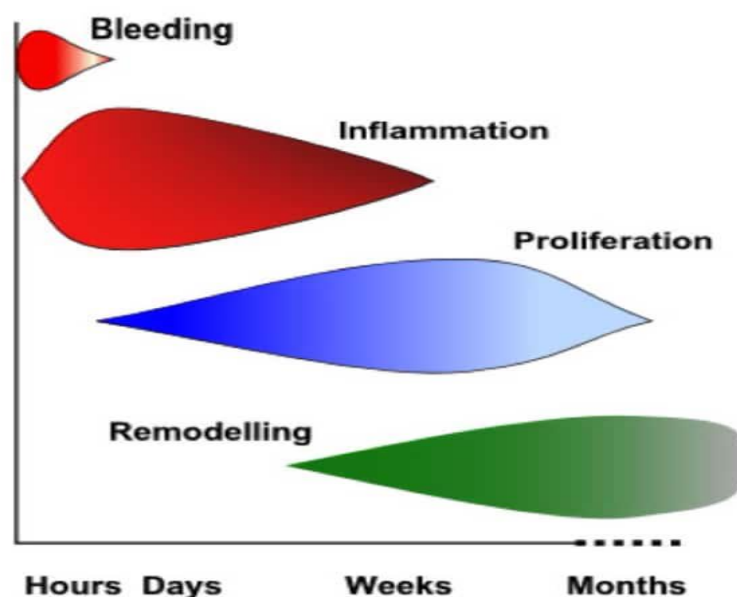


Figure 1: tissue repair Phase and Time scale.

The acute inflammation is the coordinated activation of signalling pathways that govern the amounts of proinflammatory cytokines in both resident body tissue and blood-borne pathogenic cells. Many medical conditions, including cancer, are caused by inflammation. Diabetes, arthritis, and cancer are all disorders that affect the heart and intestines. Despite being provocative, The nature of the original stimulus and its location in the brain influence response mechanisms. They all have the same mechanism in their bodies, which can be summarised as follows: 1) a cell a) Surface pattern receptors detect harmful stimuli; b) inflammatory pathways are activated. a) inflammatory markers are secreted; b) inflammatory cells are recruited; and c) inflammatory cells are recruited.

Molecular mediators^[8-10]

1. **Cytokines:** IL-1, IL-6, and TNF- α are pro-inflammatory cytokines that mediate fever, recruit immune cells, and amplify inflammation.
2. **Chemokines:** Direct immune cell trafficking to the site of infection or injury.
3. **Eicosanoids:** Prostaglandins and leukotrienes derived from arachidonic acid that modulate vascular permeability and leukocyte activation.
4. **Acute-phase proteins:** Produced by the liver in response to IL-6, including C-reactive protein (CRP) and serum amyloid A (SAA).

Cellular players^[11-15]

1. **Neutrophils:** First responders that phagocytose pathogens and release enzymes.
2. **Macrophages:** Orchestrate inflammation and tissue repair; exist in pro-inflammatory (M1) and anti-inflammatory (M2) states.
3. **Dendritic cells:** Bridge innate and adaptive immunity by presenting antigens.
4. **T and B Lymphocytes:** Participate in chronic inflammation and autoimmune responses.

Herbal plants treatment for inflammation

Achillea millefolium linn (Asteraceae)

Achillea millefolium L. is a perennial herb native to Europe and highly recognized in traditional medicine for its anti-inflammatory properties. The plant has been traditionally used externally for treatment of wounds, burns, swollen and irritated skin. Studies have shown two classes of secondary metabolites, isoprenoids and phenolics, contribute mainly to the anti-inflammatory properties^[16] Aqueous and alcoholic extracts of *A. millefolium* are used in traditional medicine internally in treatment of gastro-intestinal and hepato-biliary disorders and as an antiphlogistic drug. The topical anti-inflammatory activity of sesquiterpenes is caused by inhibition of arachidonic acid metabolism. The three flavonoids present in the crude extract and enriched in flavonoid fraction are rutin, aspigenin-7-O-glucoside and luteolin-7-O-glucoside. The crude plant extract and two fractions enriched in the dicaffeoyquinic acids and the flavonoids inhibit human neutrophil elastase as well as the

matrix metalloproteinases, which are associated with anti-inflammatory process in vitro studies.^[17]

Aconitum heterophyllum (Valeraneaceae)

A. heterophyllum is a plant which is commonly known as 'Ativisha' or 'Patis' in Ayurveda. It is used for the treatment of diseases of nervous system, digestive system, fever and rheumatism. The ethanolic extract of root of *A. heterophyllum* contains alkaloids, glycosides, flavonoids and sterols. It has been reported that plants with these chemical classes of compounds possess potent anti-inflammatory effects through inhibition of prostaglandin pathways. The cotton pellet-induced granuloma is widely used to assess the transudative and proliferative components of chronic inflammation. The weight of the wet cotton pellets correlates with the amount of granulomatous tissue. The administration of *A. heterophyllum* extract has been observed to inhibit the weight of wet cotton pellet in a dose dependent manner and the higher dose of *A. heterophyllum* exhibited inhibition of inflammation very close to the inhibitory effect of diclofenac sodium. In literature it has been reported that ethanolic root extract of *A. heterophyllum* has potential to inhibit sub-acute inflammation by interruption of the arachidonic acid metabolism.^[18]

Adhatoda vasica (Acanthaceae)

Adhatoda vasica L. is an indigenous herb belonging to family Acanthaceae. The plant has been used in the indigenous system of medicine in worldwide as herbal remedy for treating cold, cough, whooping cough, chronic bronchitis, asthma, sedative expectorant, antispasmodic, anthelmintic, rheumatism and rheumatic painful inflammatory swellings. The drug is employed in different forms such as fresh juice, decoction, infusion and powder. It is also given as alcoholic extract and liquid extract or syrup. This plant contains alkaloids, tannins, flavonoids, terpenes, sugars and glycosides.^[19] The anti-inflammatory potential of ethanolic extract has been determined by using carrageenan-induced paw edema assay, formalin-induced paw edema assay in albino rats. The ethanolic extract of *Adhatoda vasica* produced dose dependent inhibition of carrageenan and formalin-induced paw edema.^[20]

Bacopa monnieri linn. (Scrophulariaceae)

The *Bacopa monnieri* is a creeping, glabrous, succulent herb, rooting at nodes and habitat of wetlands and muddy shores.^[21] Earlier, it is used as a brain tonic to enhance memory development, learning and concentration.^[22] The plant has also been used in India and Pakistan as a cardio tonic, digestive aid and to improve respiratory function in cases of bronchoconstriction.^[23] The plant possesses anti-inflammatory activity on carrageenan-induced rat paw edema and it has shown 82% edema inhibition when compared to indomethacin. *Bacopa monnieri* also significantly inhibited 5-lipoxygenase (5-LOX), 15 (LOX) and cyclooxygenase-2 (COX-2) activities.^[24] *Bacopa monnieri* possesses significant anti-inflammatory

activity that may well be relevant to its effectiveness in the healing of various inflammatory conditions in traditional medicine.^[25] The antiinflammatory activity of *Bacopa monnieri* is due to the triterpenoid and bacoside present in the plant. The ability of the fractions containing triterpenoids and bacosides inhibited the production of proinflammatory cytokines such as tumour necrosis factor –alpha and interleukin-6. This was tested using lipopolysaccharide activated peripheral blood mononuclear cells and peritoneal exudates cells in vitro. So, *Bacopa monnieri* has the ability to inhibit inflammation through modulation of proinflammatory mediator release.^[26]

Cassia fistula L. (Caesalpinaceae)

Cassia fistula tree is one of the most widespread in the forests of India. The whole plant possesses medicinal properties useful in the treatment of skin diseases, inflammatory diseases, rheumatism, anorexia and jaundice. The bark extracts of *Cassia fistula* possess significant anti-inflammatory effect in the acute and chronic anti-inflammatory model of inflammation in rats. Reactive oxygen species (ROS) generated endogenously or exogenously are associated with the pathogenesis of various diseases such as atherosclerosis, diabetes, cancer, arthritis and aging process. ROS play an important role in pathogenesis of inflammatory diseases. The main constituents responsible for antiinflammatory activity of *Cassia fistula* are flavonoids and bio-flavonoids.^[27]

Ricinus communis Linn. (Euphorbiaceae)

Ricinus communis Linn. is found almost everywhere in the tropical and subtropical regions of the world. Anti-inflammatory and free radical scavenging activities of the methanolic extract of *Ricinus communis* root was studied by Ilavarasan et al. in Wistar albino rats. The methanolic extract exhibited significant anti-inflammatory activity in carrageenan-induced hind paw edema model. The methanolic extract showed significant free radical scavenging activity by inhibiting lipid peroxidation. The observed pharmacological activity may be due to the presence of phytochemicals like flavonoids, alkaloids and tannins in the plant extract.^[28]

Curcuma longa

It is an Indian indigenous plant.^[29] The most important secondary metabolite of *C. longa* is curcumin, which is responsible for anti-inflammatory effect of this plant.^[30]

Many clinical trials have been done for proving the anti-inflammatory effect of curcumin. Their results suggest that curcumin can be effective in improving inflammation of rheumatoid arthritis (RA) and reducing clinical manifestation of RA, such as joint swelling and morning stiffness in comparison with phenylbutazone which is used as a positive control.^[31] Also, curcumin was tested in patients with anterior uveitis; after 2 weeks, exhaustive remission occurred.^[32] The effectiveness of curcumin in patients with dyspepsia and/or gastric ulcer was proved by another clinical trial. In this study,

subjects experienced remission after 12 weeks (maximum).^[33] Curcumin is beneficial in irritable bowel syndrome (IBS) treatment^[34] and also works as a reducing agent to delayed graft rejection (DGR) after kidney transplant surgery.^[35] Curcumin likewise has a beneficial effect in inhibition of inflammatory bowel disease (IBD) and reduction in sedimentation rate in patients who suffered from IBD.^[36] It is also proven to be beneficial in maintaining amelioration of ulcerative colitis^[37] and psoriasis (by the selective prohibition of phosphorylase kinase).^[38]

CONCLUSION

Herbal plants offer a promising and sustainable alternative to conventional anti-inflammatory drugs, with numerous studies supporting their efficacy and safety profiles. The bioactive compounds found in medicinal herbs—such as flavonoids, alkaloids, terpenoids, and phenolic acids—exert significant anti-inflammatory effects through various mechanisms, including inhibition of pro-inflammatory cytokines, modulation of signaling pathways, and antioxidant activity. While traditional knowledge has long recognized the healing potential of these plants, modern scientific validation is essential to standardize dosages, ensure quality control, and fully understand their pharmacodynamics and pharmacokinetics. Continued research and clinical trials are crucial to unlocking the full therapeutic potential of herbal anti-inflammatories and integrating them into evidence-based medical practice.

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