



# Herbal Medicinal Plants with Anti-inflammatory Properties: A Comprehensive Review

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Inflammation, Herbs, Anti-inflammatory, Traditional Medicine, Secondary Metabolite, Multidisciplinary

## ABSTRACT:

Our body's natural defense mechanism against potentially harmful stimuli like allergens and/or tissue damage is inflammation. As a form of supplementary medicine, medicinal plants and their secondary metabolites are increasingly employed to treat disease. We are introducing a few herbs that have been shown in both clinical and experimental research to have anti-inflammatory effects. The herbs that are examined in the review include Neem, Mexican Poppy, *Opuntia ficus-indica*, *Bidens pilosa*, *Origanum vulgare*, *Mucuna pruriens*, *Sphaeranthus indicus*, *Solanum xanthocarpum*, and *Ricinus communis*. This review attempts to achieve a multidimensional therapeutic approach to inflammation with the use of herbal medicine and lifestyle modification because the treatment of inflammation is not a one-dimensional solution.

## 1. Introduction

Many health problems, such as allergies, cardiac difficulties, metabolic syndrome, cancer, and autoimmune disorders, are mostly caused by inflammation. There are several medications available to control and lessen inflammatory crises, but they are not without adverse effects<sup>1</sup>.

The aim is to get maximum safety and efficacy with the least amount of medicine. The most often recommended drugs for treating inflammatory-related acute and chronic pain are nonsteroidal anti-inflammatory drugs (NSAIDs)<sup>2,3</sup>. But COXs are not completely selective, and even a particular COX-2 inhibitor can inhibit COX-1, which could have detrimental consequences on the cardiovascular system<sup>3,4</sup>.

Natural remedies for a wide range of ailments may be found in medicinal plants, which is an intriguing source. The utilisation of new plant compounds for therapeutic applications has grown, and over 150,000 plant species have been researched<sup>2</sup>.

To maximise pharmaceutical efficacy and minimise side effects, natural anti-inflammatory medicines must be used in conjunction with prescription medication. In the

field of medicine, herbal medicines are highly popular, and complementary, alternative, and traditional medicine all influence prescription recommendations for them. Still, science has to validate these recommendations before contemporary medicine can proceed<sup>1</sup>.

## 2. Materials and Methods

### Materials

This study combines information from Google Scholar, PubMed, Science Direct, and Elsevier to examine the anti-inflammatory characteristics of plants and herbs. Herbs having anti-inflammatory qualities that were randomly chosen by two reviewers from English-language scholarly articles published between 2004 and the present.

Google and pertinent literature were used to obtain images, and <https://wfoplantlist.org/plant-list/> and pertinent literature were used to obtain information on plant taxonomy. By assessing the clinical data and classifying the plants and herbs according to their taxonomy, chemical makeup, and anti-inflammatory activity (in-vitro and in-vitro tests), the review seeks to give information on the anti-inflammatory activities of plants and herbs.



### Anti-inflammatory Properties of Some Medicinal Plants:

#### *Azadirachta indica* (Neem):

##### Taxonomy of *Azadirachta indica*<sup>[5]</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Eudicot
Subclass	Rosidae
Order	Sapindales
Family	Meliaceae
Genus	<i>Azadirachta</i>

**Table:1** Taxonomy of *Azadirachta indica*

##### Chemical constituents<sup>5,6</sup> :

The plant's most potent component is azadirachtin, which is followed by quercetin, gedunin, sodium nimbin, nimbin, nimbidin, nimbidol, and nimbolin. While seeds include gedunin, azadirachtin, polyphenolic flavonoids, and quercetin, leaves contain ascorbic acid, n-hexacosanol, nimbolide, and nimbiol.

##### Effect of Neem as Anti-Inflammatory<sup>5,6,7</sup>

The terpene Limonene is the main component responsible for its analgesic and anti-inflammatory action. The feet of the rats who received the dosage of 120 mg/kg of the material exhibited no formation of fibrovascular tissues and edoema. The undamaged paws served as a control. Epoxides and azadiradione restrain pro-inflammatory cytokines, leading to the modulation of macrophages' chemotaxis and anti-inflammatory effects. Utilizing *Azadirachta indica* leaves extract the research experienced the highest level of reducing inflammation of rats. The efficacy of fruit skin carbon tetrachloride derived from *Azadirachta indica* and azadiradione as antinociceptive and anti-inflammatory agents were discussed.

#### *Argemone mexicana* (Mexican Poppy)

##### Taxonomy of mexican poppy<sup>[8]</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Dicotyledons
Subclass	Magnoliidae

Order	Papaverales
Family	Papaveraceae
Genus	Argemone

**Table:2** Taxonomy of *Argemone mexicana*

##### Chemical constituents<sup>8</sup>:

The principal chemical components of *Argemone mexicana* are alkaloids, terpenoid, flavonoid, phenolic long chain aliphatic compounds, and a small number of aromatic compounds. It includes vital chemical components such as Arontianamide, Coptisine, Oxy Berberin, Allocryptopine, and Argentine. While seeds have dihydropalmitin hydroxide, berberine, protopine, and other acids, yellow juice includes berberine, Mexicanol, and Mexicanic Acid. Protomexicine, mexitin, quercetin, rutin, and 13-oxoprotopine are all found in leaves.

##### Effect of *Argemone mexicana* as Anti-Inflammatory<sup>8,9,37</sup>

The extract from *Salvia Hispanica* leaves, which has high content of isorhamnetin-3-O-glucopyranoside, amyirin, cysteine, and phenylalanine, reduces strongly inflammation in rats. It was determined that the most active ingredient was ethyl acetate since it has anti-inflammatory properties when applied to a carrageenan-induced paw edoema model.

Similar to indomethacin, the ethanolic extract works on the cyclooxygenase enzyme and reaches its maximal potency at 250 mg/kg. Alkaloids, phytosterols, flavonoids, phenolic components and tannins are found to be there in the extract.

#### *Opuntia ficus-indica* (prickly pear)

##### Taxonomical of *Opuntia ficus-indica*<sup>[40]</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Eudicots
Order	Caryophyllales
Family	Cactaceae
Subfamily	Opuntioideae
Genus	<i>Opuntia</i> Mill

**Table:3** Taxonomy of *Opuntia ficus-indica*



### Chemical composition<sup>24,25</sup>

D-glucose, D-galactose, L-arabinose, D-xylose, L-rhamnose, D-galacturonic, and glucuronic acids are among the sugars found in plant mucilage. While rutin, quercetin, kaempferol, penduletin, and luteolin are recognised as flavonoids, hexoses and pentoses are present in variable levels. Plants belonging to the Cactaceae family include flavonol 3-O-glycosides, dihydroflavonols, flavonones, and flavonols. The fruit of the cactus pear has pigments called betalain that may be used as a natural culinary colouring. In addition to other organic acids including maleic, malonic, succinic, tartaric, and oxalic, *Opuntia ficus indica* fruits contain ascorbic acid. Together with minerals including calcium, magnesium, sodium, potassium, phosphorus, and iron, the fruit also includes vitamins B1, B6, E, and A.

### Effect of *Opuntia ficus-indica* as Anti-Inflammatory<sup>24,25,26</sup>

It has been proven that *Opuntia ficus indica* has anti-inflammatory effects attributed to sitosterol found in the stem extract. Fruit extracts have been observed to possess anti-inflammatory properties not only in animals and humans. Yellow fruit in a diet protected obesity-related cardiac damage, reduced leukocyte migration in a mice and rats, and had a great anti-inflammatory effect on carrageenan-induced pleurisy. Also, in adult rats (male Sprague-Dawley) of chloride-aluminium neurotoxicity, pulp, or peel extract declined levels of TNF- $\alpha$ , NF- $\kappa$ B, and IL-1 $\beta$ .

### *Bidens Pilosa* L. (Spanish needles)

#### Taxonomy of *Bidens Pilosa* L.<sup>[14,15]</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Magnoliopsida
Subclass	Asteridae
Order	Asterales
Family	Compositae
Genus	<i>Bidens</i>

**Table:4** Taxonomy of *Bidens pilosa*

### Chemical constituents<sup>14,16</sup>:

*Bidens Pilosa* L. has the various class of chemical constituents as polyacetylenes, polyacetylenic

glycosides, aurons, auron glycosides, p-coumaric acid derivatives, caffeoylquinic acid derivatives, flavonoids and flavonoid glycosides, sesquiterpenes, acetylacetone, phenylheptadiynol, phenylpropanoid glycosides, pheophytins, diterpenes.

### Effect of *Bidens Pilosa* as Anti-Inflammatory<sup>14,15,16,17</sup>

*In vitro* experiment suggested a unique effect as *Bidens Pilosa* suspended in CMC-Na capable of being modeled as a type I allergy of the host immune system. After 10 days of immunizing, the serum level of IgE increased and the *Bidens Pilosa* dose was related to a reduction in them. The inference is that with the help of the adaptations effects of Helper T cell profile *Bidens Pilosa* or its flavonoids, IgE production is reduced.

### *Origanum vulgare* (Origanum)

#### Taxonomical classification<sup>[41]</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Magnoliopsida
Subclass	Asteridae
Order	Lamiales
Family	Lamiaceae
Genus	<i>Origanum</i>

**Table:5** Taxonomy of *Origanum vulgare*

### Chemical constituents<sup>18,19</sup>:

*Origanum vulgare*, a plant found in the Mediterranean basin, is primarily composed of thymol and carvacrol, which are the main metabolites. The dried plant material also contains phenolic glycosides, flavonoids, terpenoids, tannins, and essential oils. Luteolin 7-O-glucoside and Luteolin O-glucuronide are the main flavonoid components found in hydroalcoholic extracts, infusions, and decoctions. Rosmarinic acid is traditionally the main phenolic acid, while vanillic acid, O-coumaric acid, and protocatechuic acid have also been discovered. *Origanum vulgare*'s essential oils contain acyclic, bicyclic, and sesquiterpene compounds. Subspecies growing in the southern Mediterranean basin are enriched in essential oils with monoterpenoids, accounting for at least 70% of total oil production. These subspecies are poor sources of volatiles.



### Effect of *Origanum vulgare* as Anti-Inflammatory<sup>18,19</sup>

*Origanum vulgare* leaf extract (1.5, 2.25, and 2.7 mg/ml) was shown to be efficient in inhibiting iNOS on microglial cells and activated mixed cells in studies on the plant's anti-inflammatory properties. *Origanum vulgare* extracts reduce pro-inflammatory cytokines (TNF- $\alpha$  and IL-6) and NO without affecting cell viability, according to a 2021 study by Mir, R.H. *et al.*

### *Mucuna pruriens* Linn. (Velvet Bean)

#### Taxonomy of *Mucuna pruriens* Linn.<sup>21</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Magnoliopsida (Dicote, Dicotyledon)
Subclass	Rosidae
Order	Fabales
Family	Leguminosae
Genus	<i>Mucuna</i>

**Table:6** Taxonomy of *Mucuna pruriens*

#### Chemical constituents<sup>21,22,23</sup>

Large amounts of L-Dopa are present in the seeds of the plant *Mucuna pruriens*. Alkaloidal substances such as lecthin, amino acids, and mucunadine, mucunine, and prurienidine are present in it. Phytochemicals found in the plant include 1-methyl-3-carboxy-6, 7-dihydroxy-1,2,3,4-tetrahydroisoquinoline, 5-hydroxytryptamine, 5-methoxy-n,n-dimethyltryptamine-n-oxide, 5-oxyindole-3-alkylamine, 6-methoxyharman, arginine, aspartic acid, alanine, behenic acid, carboline, and sitosterol. *Mucuna pruriens* seed n-hexane extract yielded three new lipid compounds that were described. It has been possible to isolate four tetrahydroisoquinoline alkaloids from the plant, which also includes minerals.

#### Effect of *Mucuna pruriens* Linn. as Anti-Inflammatory<sup>23</sup>

In LPS-stimulated BV2 microglial cells, *M. pruriens* seed extract dramatically decreased inflammatory mediators, reducing TNF- $\alpha$ , IL-1, and IL-6 protein production. Additionally, it inhibited NF- $\kappa$ B signalling, indicating that it may be used in alternative and traditional therapy to treat Parkinson's disease.

### *Sphaeranthus indicus* Linn. (Kottakarantai)

#### Taxonomic Classification<sup>27</sup>

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Magnoliopsida
Subclass	Asteridae
Order	Asterales
Family	Asteraceae
Genus	<i>Sphaeranthus</i>

**Table:7** Taxonomy of *Sphaeranthus indicus*

#### Chemical constituents<sup>27,29</sup>:

Cicacoid, among other chemicals, is produced by *S. indicus*, a plant that is well-known for its sesquiterpenoids. Also detected are eudesmanoids, such as 11-, 13-dihydro-3-, 7-dihydroxy-4,5- epoxy-6, 7-eudesmanolide, 11-, 13-dihydro-7-acetoxy-3-hydroxy-6, 7-eudesm- 4-enolide, and 3-keto-eudesmol. An extract of *S. indicus* aerial parts in petroleum ether has revealed the presence of a bicyclic sesquiterpene lactone. The aerial section has also yielded the isolation of 5-hydroxy-7-methoxy-6-C-glycosylflavone, a flavonoid C-glycoside. A rich cherry-colored essential oil that is extracted from the plant also includes methyl chavicol, d-cadinene,  $\alpha$ -ionone, p-methoxycinnamaldehyde,  $\alpha$ -terpinene, citral, geraniol, geranyl acetate,  $\beta$ -ionone, oscimene, eugenol, sphaeranthene, sphaeranthol, estragole, Indicusene, and alkaloid sphaeranthine. According to studies, *S. indicus* leaves include carbohydrates such as arabinose, galactose, glucose, fructose, lactose, maltose, raffinose, and rhamnose. Additionally, leaves have been used to isolate the isoflavone glycoside 5,4'-dimethoxy-3'-prenylbiochanin 7-O-d-galactoside. Phaeranthanolide is a sesquiterpene glycoside found in *S. indicus* flowers that has immune-stimulating properties.

#### Effect of *Sphaeranthus indicus* as Anti-Inflammatory<sup>27,27,28</sup>

Reactive oxygen species and pro-inflammatory cytokines are important inflammatory mediators in the pathophysiology of acne, and research has shown that the herb *S. indicus* has anti-inflammatory qualities by lowering their production. The TNF- $\alpha$  and IL-8 production induced by *P. acnes* was dramatically



decreased by the *S. indicus* root extract. In both acute and chronic inflammation models, the herb's anti-inflammatory properties were also shown, with dose-dependent and substantial anti-inflammatory impact at various dosages (100, 200, and 400 mg/kg, p.o.).

### ***Boerhaavia diffusa* L. (Punarnava)**

#### **Taxonomy of *Boerhaavia diffusa*<sup>[10]</sup>**

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Magnoliopsida
Subclass	Caryophyllidae
Order	Caryophyllales
Family	Nyctaginaceae Juss.
Genus	Boerhaavia L.

**Table:8** Taxonomy of *Boerhaavia diffusa*

#### **Chemical Constituents<sup>10,11,12,38</sup>**

Many rotenoids are produced by the roots of *Boerhaavia diffusa*, such as punarnavoside, C-methyl flavone, lignans such as liriiodendrin and syringaresinol mono-D-glycoside, and phytosterols such as dihydroisofuroxanthone-borhavine. Punarnavine and punarnavoside, two of the plant's alkaloids, have antifibrinolytic properties.

Its composition is about 6% potassium nitrate and ursolic acid. Fatty acids, allantoin, and alkaloids are present in the roots and seeds. The green stem of the plant contains boerhavin and boerhavic acid as well. Additionally, fatty acids, alkaloids, and allantoin are found in the plant's roots and seeds.

#### **Effect of *Boerhaavia diffusa* as Anti-Inflammatory<sup>[10,12,13,38,39]</sup>**

*In vivo* research on rats showed that *Boerhaavia diffusa* leaf and flower extracts reduced edema by 55.78%. The extracts reduced abdominal writhing in mice by 50 and 47% compared to dipyron sodium. The juice and lyophilized decoction of the leaves also delayed mice's hot plate testing.

*Boerhaavia diffusa* roots were used to isolate sitosterol, reducing edema by 61.29%. The plant is commonly used to treat inflammation, with extracts including liriiodendrin, quercetin, and kaempferol. The root extract

is effective in protecting albino rats from carageenan-induced oedema and arthritis.

### ***Solanum xanthocarpum* (Yellow Berried Night Shade):**

#### **Taxonomic classification<sup>[30,31]</sup>**

Kingdom	Plantae
Subkingdom	Tracheobionta
Class	Magnoliopsida
Subclass	Asteridae
Order	Solanales
Family	Solanaceae
Genus	Solanum

**Table:9** Taxonomy of *Solanum xanthocarpum*

#### **Chemical constituents<sup>30,31</sup>:**

Alkaloids, sterols, flavonoids, saponins, carbohydrates, fatty acids, amino acids, and other substances are found in plants. The fruit of French plants contains more solasodine glycoside than that of Nepalese species. India's Jammu & Kashmir produces fruits with a higher glycoalkaloid content. Diosgenin<sup>19</sup> is present in Calcutta plants, which also provide an oil that is characteristically greenish yellow in colour and has a particular scent. One of the two sterols found in the seeds is campesterol.

#### **Anti-inflammation Effect of *Solanum xanthocarpum*<sup>30,31,32,33</sup>**

Lupeol, a component of *S. xanthocarpum* fruits, has anti-inflammatory properties and can protect healthy cells and tissues. It also has anti-fecundity, anti-rheumatic, anti-carcinogenic, and hypoglycemic properties. A study analyzed the five components of *S. xanthocarpum* to inhibit nitric oxide production in LPS-stimulated RAW 264.7 cells in Wistar Albino rats.

### ***Ricinus communis* Linn.**

#### **Taxonomical classification<sup>[34]</sup>**

Kingdom	Plantae
Order	Malpighiales
Family	Euphorbiaceae
Genus	Ricinus

**Table:10** Taxonomy of *Ricinus communis*



**Chemical constituents<sup>34,35</sup>:**

In the early phytochemical investigation of *R. communis*, steroids, saponins, alkaloids, flavonoids, and glycosides were discovered. The dried leaves included 1, 8-cineole, camphor, sesquiterpenoid (-caryophyllene), flavones, glycosides, kaempferol, kaempferol-3-o-D-glucopyranoside, quercetin-3-O-monoterpenoids, N-demethylricinine (0.55%), ricinine (0.55%), and epic.

**Anti-Inflammatory Activity of *Ricinus communis*<sup>34,35,36</sup>**

In the research about the anti-inflammatory effect on rats by the methanolic leaves and aqueous root extracting of *R. communis*, it was found that the inflammation of paw wasn't achieved by the carrageenan-subplantar, but was campualted at the doses of 250 and 500 mg/kg by the methanolic leaves.

**3. Discussion**

In order to minimize bias, the methods used to collect the literature were specific to our study; the details of the anti-inflammatory effects of particular herbs that we studied in this paper are mentioned on the original literature with supporting data.

Si. no.	Herbs	iNOS	TNF- $\alpha$	IL	LOX	PGE2	Nox	suppress the production of	IgE	NO	NF- $\kappa$ B
1.	<i>Azadirachta indica</i>		✓	✓							✓
2.	<i>Argemone mexicana</i>				✓						
3.	<i>Opuntia ficus-indica</i>		✓	✓		✓	✓				

4.	<i>Bidens Pilosa</i> L.										✓	
5.	<i>Origanum vulgare</i>	✓	✓	✓								✓
6.	<i>Mucuna pruriens</i> Linn.		✓	✓								✓ ✓
7.	<i>Sphaeranthus indicus</i> Linn.		✓	✓								
8.	<i>Boerhaavia diffusa</i> L.	✓	✓									✓
9.	<i>Solanum xanthocarpum</i>											✓ ✓
10	<i>Ricinus communis</i> Linn.		✓	✓								

**Table 11:** Mechanism of Anti-inflammatory action of listed plants

Note: iNOS:Inducible nitric oxide synthase, TNF- $\alpha$ : Tumour necrosis factor  $\alpha$ , IL: Interleukines, LOX: Lipid oxygenase enzyme, PGE2: Prostaglandin E2, NOX: NADPH oxidases, IgE: Immunoglobulin E, NO: nitric oxide, NF- $\kappa$ B: nuclear factor kappa B

The mechanism given here is based on references; there may be other mechanisms that we haven't included that the herbs use to create their anti-inflammatory effects.



#### 4. Conclusion:

We have included the herbs about which there is more evidence because there are so many plants that have been claimed to have anti-inflammatory effects that it would be impossible to evaluate them all in this paper.

One of the most crucial components of supplementary therapies is herbal medicine. There are numerous studies that support the use of various herbs in the remission of inflammation. With the help of clinical and experimental studies, we have presented herbs with anti-inflammatory properties; however, these herbs do more than only reduce inflammation. Inhibition of TNF- $\alpha$  (tumor necrosis factor- $\alpha$ ) and interleukines are the most prevalent in the above-mentioned herbs, although these plants also have other anti-inflammatory effects. It should be noted that the term "natural anti-inflammatory" encompasses natural substances as well as lifestyle factors including exercise, sleep, and dietary habits. Numerous studies have been conducted on natural substances and herbal remedies, but the results of those studies have been mixed and inconsistent. In some cases, the extraction process directly affects the chemical components, and this must be taken into account because each medicinal herb's pharmacological effect is the result of a variety of metabolites combined with their synergistic effects; perhaps this is one of the causes of paradoxical results. In another case, taking into account a plant's side effects, contraindications, and pregnancy qualities is a crucial matter that calls for extreme prudence on the part of the practitioner, yet there is almost no trustworthy evidence about these. Additional evidence-based research and meta-analyses may be able to give health practitioners a clearer perspective and strategy.

#### 5. Conflict of Interest:

The authors have no conflicts of interest regarding this investigation.

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