Botanical Allies: Exploring the Anti-Inflammatory Properties of Medicinal Plants

CHAPTER 11

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SUMMARY

Plants alongside being the primary source of food, played their role as a medicine as well. Plants being rich in therapeutic potential due to their phytochemical profile have been in medicinal use since ancient times and have always been an interest to clinical trials as well as research. Being less harmful and natural, plant derived medicines are a great alternative to conventional medicines. The biologically active compounds in plants i.e., phytochemicals are capable of showing biological activities. One of the important properties of therapeutic plants is their anti-inflammatory potential. Different plants from different regions of the world have been proven to possess the potential of reducing inflammation caused by different agents. Inflammation is the body's response to harmful stimuli. Plant derived medicine could be in the form of extract and powdered supplements. Extract of different parts of a therapeutic plant has been helpful in treating induced inflammation in clinical trials along with conventional medicines as well as alone. Plants having anti-inflammatory potential such as Aegle marmelos, Bryophyllum pinnatum, Albizia lebbeck, Cassia occidentalis, Cynodon dactylon and Zingiber officinale have been discussed in this chapter to emphasize their action against causative agents.

INTRODUCTION

Plants have more than 500,000 species estimated globally. Each species has a unique variety along with complex properties. People have been using plants for centuries for various purposes, and curing diseases is the most important. It is said that more than 150,000 species of plants have been studied which possess therapeutic effects. Due to the plant's complex chemical profile, they can participate in biological activities. Plant-based medicines have always been an interesting part of clinical research and drug industries. According to the World Health Organization (WHO), around 65% of the population globally includes plant-based medicine in their health management. To attack pathogens and protect from environmental stress, plants produce different chemical substances. These substances are the result of secondary metabolism. Plants have great anti-inflammatory potential due to their phytochemical constituents (Nunes et al., 2020). Inflammation can be described as a protective reaction of the body that involves the onset of the immune system against infection, harmful compounds, damaged cells, or exposure to harmful radiation to maintain the body's homeostasis. Inflammation can be acute or chronic depending on the damage to the body (Oronsky et al., 2022). Compared to conventional medicines, plant-based medicines due to their phytochemical profile (Table 1) have helped treat and manage inflammation (Nunes et al., 2020).

AEGLE MARMELOS

Aegle (*A.*) *marmelos* bearing numerous medicinal benefits of family Rutaceae usually known as Bael, Japanese bitter orange, Bengal quince, golden apple, stone apple or wood apple, etc. is a tree native to the Indian subcontinent and Southeast Asia. It also naturally grows in India, Pakistan, Bangladesh, Sri Lanka, and Nepal. It is the only plant that belongs to the genus Aegle. *A. marmelos* is a broad-leaved woody plant or small to medium-tall tree with a height of 13 meters (Sharma et al., 2022a). The Bael tree has spiky steam branches that can be seen. The alternating, usually trifoliate leaves have 3 to 5 leaflets per leaflet, each measuring 4 to 10 centimeters in length and 2 to 5 centimeters in width. When leaves are young, they are a relatively lighter shade of green; as they mature, they turn a dark green color. The tree has thick, peeling bark with limbs that are frequently spiky. There is a gum discharge from the injured bark that thickens in the presence of air. The Bael flower has a greenish-white hue. It is characterized by a fragrant aroma and an actinomorphic, bisexual, ebracteate, hypogynous stalk. 10 flowers are seen in

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Table 1. Showing phytochemical profile of anti-inflammatory potential-rich plants

Phytochemical	*A. marmelos* (Sharma et al., 2022a)	*B. pinnatum* (Kumar et al., 2020)	*A. lebbeck* (Sharma et al., 2022b)	*C. occidentalis* (Ujah et al., 2022)	*C. dactylon* (Savadi et al., 2020)	*Z. officinale* (Christine et al., 2021)
Alkaloids	+	+	+	+	+	+
Glycosides	+	+	+	+	+	+
Flavonoids	+	+	+	+	+	+
Terpenoids	+	+	+	+	+	+
Phenols	+	+	+	+	+	+
Saponins	+	+	+	+	+	+
Tannins	+	+	+	+	+	+

lateral panicles that are located in the leaf axil. The Bael fruit has a mostly yellowish green color and is 5.3–7.2 cm in diameter. Its approximate weight is 77.2 g, its volume is 73.7 mL, and its sphericity is 93.72%. The fruit's pulp has a yellow color and is sticky. It has a few spots on the outside and a large number of firm seeds with white thread-like hairs covering their outside surface. Every part of this tree at a certain maturity and age provides various medicinal benefits, making it a pharmacologically important plant (Sharma et al., 2022a).

Phytochemical Constituents and Anti-inflammatory Mechanism

This native tree has several coumarins, glycosides, carotenoids, polyphenols, flavonoids, pectins, triterpenes, alkaloids, tannins, sterols, saponins, psoralen, and essential oils granting medicinal properties to the plant [Fig. 1 (Sharma et al., 2022a)]. Extract derived from *A. marmelos* leaves and fruit has shown anti-inflammatory activity by inhibiting mediators in vitro. Coumarin, a special phytochemical isolated from *A. marmelos*, has been scientifically proven to have significant anti-inflammatory potential compared to commercial medicines (Tiwari et al., 2023). Crude extract, methanolic extract, and coumarin-enriched extract of *A.* marmelos fruit pulp have shown remarkable anti-inflammatory effects along with anti-diabetic potential by inhibiting responsible enzymes in vitro and silico. Extract of *A. marmelos* leaves has been proven to treat acute inflammation in carrageenin-induced rat paw edema model, administered orally (200mg/kg B.) (Ramadoss & Vishnupriya, 2023).

BRYOPHYLLUM PINNATUM

Bryophyllum (*B.*) *pinnatum* of family Crassulaceae, is widely naturalized in Australia, topical eastern Africa (Madagascar), New Zealand, Asia (e.g., India, Taiwan, Indonesia, and New Guinea), the Caribbean, south-eastern USA (i.e., Florida) and the Pacific (i.e., the Galapagos Islands, Melanesia, Polynesia, and Hawaii). It has many common names such as Pan photo, Resurrection plant, Leaf of life, Life plant, Live leaf, green mother of millions, Air plant, Canterbury bells, Cathedral bells, good luck leaf, Curtain plant, and Mexican love plant, etc. 60-120cm tall plant with broad and scalloped margin oppositely arranged leaves (Mule et al., 2020). The leaves decussate and are 10–20 cm long. Surrounding the 3 to 7-foliate upper leaf is a lengthy petiole. With red ribbons scalloping them, they have a dark green color. Latent buds that can form into healthy plantlets with an acute tip are present in the 30-35 cm long, 2-4 cm petiole, and 7-8 X 3-5.5 cm blades. On the leaves are vegetative buds that are rooted. The Paniculate terminale has a length of 10–40 cm.

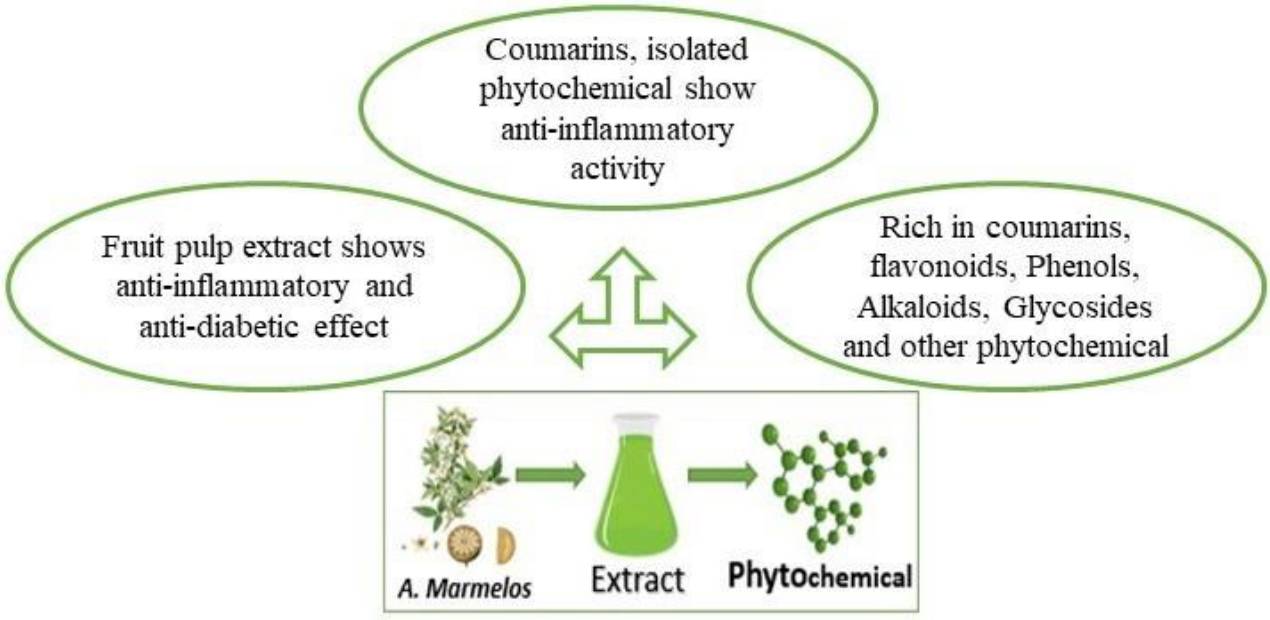

Fig 1. Anti-inflammatory mechanism of *Aegle marmelos*

Flowers in the shape of pendulous bells cover the ground. With follicles in the petals and calyx, oblong stamens, and oval-shaped nectar scales, the calyx tube is 2-4 cm long. The smooth, ellipsoid seeds are plentiful and found in the four-septate fruit pod. November to March is when the plant produces the most. The aftertaste of this is spicy, astringent, acidic, and sweet (Selvakumar, 2022).

Phytochemical Constituents and Anti-inflammatory Mechanism

Phenols, alkaloids, flavonoids, saponins, tannins, carotenoids, glycosides, sitosterol, anthocyanin, malic acid, terpenoids, quinines, tocopherol, lectins, coumarins and the key component are Bufadienolides-Bryophyllin A (bryotoxin)15; Bryophyllin B, are present in air plant (Kumar et al., 2020). *B. pinnatum* leaves extract, flowers, seeds, and recent studies have shown that its root powder has anti-inflammatory potential due to its phytochemical profile, strong enough to inhibit the mediators (Selvakumar, 2022; Singh et al., 2022; Latif et al., 2020). *B. pinnatum* decreases the potency of tissue necrosis factor by inhibiting cyclooxygenase enzyme. Leaf and flower aqueous extract helped to reduce inflammation in carrageenan-caused paw edema when tested in rats (Fig. 2). Leaves methanolic distillate remarkably inhibits edema in comparison to standard drugs (Selvakumar, 2022; Singh et al., 2022; Latif et al., 2020).

ALBIZIA LEBBECK

Albizia (*A.*) *lebbeck* is indigenous to the Indian subcontinent and Myanmar is a plant belonging to the family Fabaceae. It is generally grown and naturally grows in more humid and warm areas, including Australia. It has many usual names such as siris, Indian siris, East Indian walnut, Broome raintree, lebbeck, lebbek tree, fry wood, Koko, and woman's tongue tree, etc. (Sharma et al., 2022b). Many medical systems, including Ayurveda, Sidha, and Unani medicine, advocate it. It has a wide range of traditional applications; among them, the majority involve treating respiratory disorders (16%), skin disorders (11%), gastrointestinal disorders, and oral disorders 7%). Within all of these traditional and ethnomedical contexts, the plant is commonly used to treat a variety of ailments, including ulcers, scorpion stings, leprosy, boils, bronchitis, diarrhea, and gum inflammation (4.88%), piles (4.27%), parasitic infestation and snakebite (3.66%), and abdominal tumors, arthritis, cough, dysentery, night blindness, and poisoning (2.44%). With 33.33% of all plant parts utilized, the bark is the most commonly used. It is followed by leaves, flowers, seeds, roots, bark, stems, and pods (16.67%) (Balkrishna et al., 2022). Genus Albiza also has a common name i.e., Siris, because of the rattle sound produced by seeds inside the pods. 18-30 m tall tree (50cm-1m in diameter trunk), bipinnate leaves (7.5–15 cm long with 1 to 4 pairs of pinnae, each pinna with 6–18 leaflets) and very fragrant white flowers (numerous 2.5–3.8 cm long stamens). The fruit is in the form of a pod 15–30 cm long and 2.5-5.0 cm broad, containing six to twelve seeds (Sharma et al., 2022b).

Phytochemical Constituents and Anti-inflammatory Mechanism

The phytochemical profile of *A. lebbeck* consists of alkaloids, anthraquinones, essential oils, flavonoids, glycosides, phenolics, phytosterol, tannins, saponins, steroids, and triterpenoids. Its seeds are a good source of protein 2.272%, lipids 0.27%, fatty acid (linolenic acid, oleic acid, palmitic acid, and steric acid), tetradecane, hexadecane, phytol, nonadecane, eicosane, vitamin E, stigmastadiene, and octadecane (Sharma et al., 2022b). All parts of the plant performed anti-inflammatory action when tested. Aqueous leaf extract of *A. lebbeck* by inhibiting protein denaturation, showed anti-inflammatory activity (Kamala & Valarmathi, 2020). In animal models, the anti-inflammatory effect of *A. lebbeck*'s various solvent extracts on acute as well as chronic

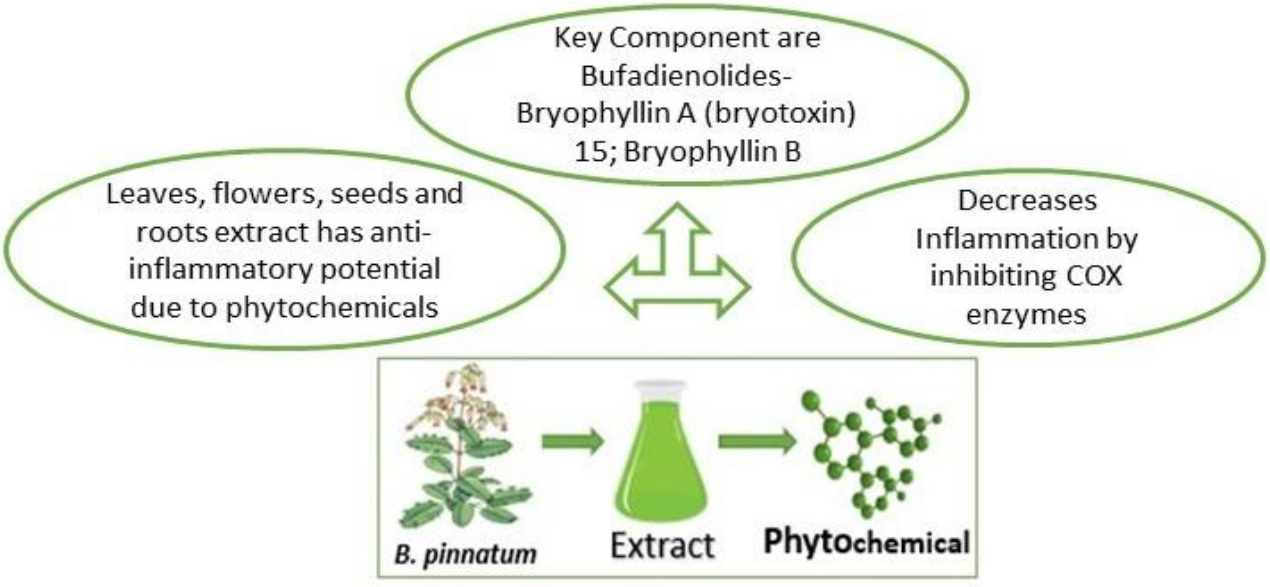

Fig 2. Anti-inflammatory mechanism of *Bryophyllum pinnatum*

inflammation and effect of the extract in carrageenan-induced edema has been studied. Drug extract has shown remarkable potency in anti-inflammatory activity and has shown effects on adjuvant arthritis by eliminating paw edema (Balkrishna et al., 2022).

CASSIA OCCIDENTALIS

Cassia (*C.*) *occidentalis* is known as Senna occidentalis as well. A weed linked to the breed Fabaceae. Senna occidentalis is indigenous to the humid and warm areas of America and naturalized in Australia, southern and eastern USA, and eastern Africa (Khurm et al., 2021). It has various common names such as Coffee senna, ant bush, arsenic bush, negro coffee, Nigerian senna, septic-weed, sicklepod, stinkweed, stinking pea, stinking weed, styptic weed, etc., (Pawade & Jane, 2020). Its leaves, stems, and roots have all been widely used in traditional medicine to treat urinary tract, liver, and flu conditions as well as as a laxative, painkiller, and vermifuge. Sometimes, the seeds are roasted and used to make drinks that resemble coffee. Additionally, Laboratorio Pernambucano Ltd. (LAPERLJ) marketed the extractives of *C. occidentalis* L. leaves, stems, and roots under the trade name "Cassia virginica" in Brazil. These products were intended to treat fever, TB, flu, and other illnesses, as well as to function as a diuretic (Sayed et al., 2023). 1-2 m tall stinking shrub which has soft bushy branches and stems. 3-7 pair pinnate leaves, commonly elliptic to egg-shaped leaflets. Yellow coloured flowers are attached on the end of branchlets in 2-4 groups and each flower has 6 fertile stamens. This weed is broadly scattered all over the humid region of the earth (Pawade & Jane, 2020)

Phytochemical Constituents and Anti-inflammatory Mechanism

Senna occidentalis phytochemical profile shows the presence of flavonoids, alkaloids, glycosides and terpenoids in high amounts. While saponins, phenol, tannins, and steroids are present in moderate amounts. Its phytochemical screening also shows the presence of vitamins such as vitamin A, vitamin B, vitamin B1, vitamin B2, vitamin B3, vitamin C, vitamin D, vitamin E and vitamin K (Ujah et al., 2022). Some noteworthy components are aloe-emodin, chrysophanol, nerolid, apigenin, 1-methoxy naphthalene and quinine. Investigation has shown that Senna occidentalis extract has anti-inflammatory ability by blocking the activity of cyclooxygenase-2 (COX-2) protein and lipoxygenase (LOX) protein. Senna occidentalis extracts in vitro, displayed anti-inflammatory action by hindering the making of pro-inflammatory cytokines such as interleukin-1β and tumor necrosis factor-alpha. This happens might be because of the plant's capability of altering the action of enzymes associated with inflammation, such as cyclooxygenase-2 (COX-2) and lipoxygenase (LOX) (Shyeed et al., 2023).

CYNODON DACTYLON

This grass belongs to the family Poaceae. *Cynodon* (*C.*) *dactylon* is found worldwide (New Zealand, Europe, Africa, Australia and in many countries of Asia). It was brought to America. It is commonly called as Couch grass and Bermuda grass. It is not an Indigenous plant of Bermuda but aggressively grows there and is called as crabgrass. Various common names are dhoob, ethane grass, dubo, Bahama grass, durva grass, dog grass, dog's tooth grass, devil's grass, grama, Indian doab, wire grass, arugampul, scutch grass, etc. (Das et al., 2021). *C. dactylon* is described as having a strong, sharp flavor and a pleasing scent in the Unani medical system.In addition to their cardioprotective qualities, the plant's rhizomes and aerial parts have diuretic, antidiabetic, antibacterial, antimicrobial, antioxidant, and wound-healing qualities. *C. dactylon* is used by traditional healers to treat gonorrhea, diarrhea, conjunctivitis, anuria, and stomachaches. It also makes the blood pure (Amritkar et al., 2023). 1-30 cm tall, generally tinged purple coloured and flattened stem with grey green colour short and rough-edged blades. Seed heads are attached at the top of stem in form of cluster of 2-6 spikes. Root system is very deep. Usually, root mass is not greater than 60 cm in depth. But in case of drought and fertile soil root system can go over 2 metres in depth (Das et al., 2021).

Phytochemical Constituents and Anti-inflammatory Mechanism

This widely spreading grass bears a good phytochemical profile consisting of glycosides, alkaloids, terpenoids, flavonoids, saponins, resins, triterpenoid esters, tannins, carbohydrates, phytosterols, proteins, phenols, reducing sugars, fixed as well as volatile oils (Savadi et al., 2020). Aqueous and alcoholic extract of couch grass has experimentally shown good anti-inflammatory action by inhibiting protein denaturation. Alcoholic extract showed better action as compared to aqueous extract in vitro. In carrageenan-caused edema in paws of rat, *C. dactylon* extract showed anti-inflammatory action by inhibiting histamine and serotonin. Anti-inflammatory action is due to the reduced pharmacological activity of histamine. The high flavonoid content of this grass can reduce the synthesis of prostaglandins (Akhlaq et al., 2024).

ZINGIBER OFFICINALE

The plant *Zingiber* (*Z.*) *officinale*, Zingiberaceae is used as a spice in food all around the world. Ginger is a perennial plant native to tropical Asia that is grown in tropical regions of Australia, Brazil, China, India, Jamaica, West Africa, and some areas of the United States. Chinese and Ayurvedic medicine have traditionally used ginger rhizome as an antipyretic, antiemetic, and anti-inflammatory (Kumari et al., 2020). Ginger has been utilized as an herb for thousands of years because of its wide range of phyto-therapeutic properties. In Ayurveda, ginger is called Mahaaushdi, which suggests that it improves internal functions and helps flush the body of toxins. Moreover, the components of this substance have been shown to treat the symptoms of arthritis, muscle aches, chest pain, lower back pain, stomach pain, and menstrual pain, indicating that ginger is a pain reliever. Other illnesses that can be treated with ginger include upper respiratory tract infections, coughs, and bronchitis. The rhizome is advised for use in treating joint issues because it can also lower inflammation (Edo et al., 2024).

Phytochemical constituents and Anti-inflammatory mechanism

The components of ginger are diverse and can differ based on the region of origin and the state of the rhizomes, but here is a summary of the main ones that have been linked to the crude drug's pharmacological effects. Gingerol is the main pungent ingredient in ginger (phenylalkylketones or vanillyl ketones); significant concentrations of other gingerol analogs, including shogoals, paradol, and zingerone, are also present in rhizome extracts. It seems that gingerol and shogaol are the main pharmacological components of ginger (Sindhoora & Bhattacharjee, 2020). Ginger has been found to inhibit prostaglandin biosynthesis and interfere with the inflammatory cascade and the vanilloid nociceptor (Pazmzndi et al., 2024). There is a long history of using ginger as an anti-inflammatory, and numerous of its ingredients have been shown to have anti-inflammatory qualities. Ginger extract derived from *Z. officinale* inhibits the induction of various genes that are implicated in the inflammatory response, such as those that encode chemokines, cytokines, and the inducible enzyme cyclooxygenase-2. This discovery provided evidence that ginger modulates biochemical pathways activated in chronic inflammation (Azeez & Lunghar, 2021).

CONCLUSION

Although the body naturally responds to injury or infection with inflammation, persistent inflammation can result in several illnesses. These illnesses can give birth to serious health *issues* if left unchecked. Plants are rich in miraculous components which offer a bunch of therapeutic services. In this review, numerous therapeutic plants with anti-inflammatory qualities have been investigated, including A. marmelos, *B. pinnatum*, *A. lebbeck*, C. occidentalis, *C. dactylon*, and *Z. officinale*. A. marmelos, often referred to as Bael, the abundance of phytochemicals found in A. marmelos, such as tannins, flavonoids, and coumarins, is thought to be responsible for its anti-inflammatory qualities. *B. pinnatum* is distinguished by its capacity to multiply from leaf buds. This succulent's leaves are rich in bioactive substances with notable anti-inflammatory properties, such as glycosides, triterpenoids, and flavonoids. Because *B. pinnatum* reduces swelling and inflammation. *A. lebbeck* is utilized in traditional medicine for its leaves, bark, and seeds. The saponins, tannins, and flavonoids found in *A. lebbeck* are primarily responsible for its anti-inflammatory properties. Cassia occidentalalis, often referred to as coffee senna, this plant is used for its strong anti-inflammatory qualities in its seeds, leaves, and roots. The plant's anti-inflammatory properties are facilitated by the presence of tannins, flavonoids, and anthraquinones. Bermuda grass, *C. dactylon* is valued for both its medicinal and robust qualities. Phytochemicals found in the grass, including glycosides, alkaloids, and flavonoids, have anti-inflammatory properties. *Z. officinale* commonly called as ginger, is well-known for its therapeutic and culinary applications. Strong anti-inflammatory bioactive substances like paradol, shogaol, and gingerol are found in the rhizome. The potential of ginger to lower inflammation in diseases like rheumatoid arthritis, osteoarthritis, and gastrointestinal issues has been thoroughly investigated. Ginger has anti-inflammatory properties that are mediated by suppression of pro-inflammatory cytokines and inhibition of the COX and lipoxygenase pathways. All these plants have been in medicinal practices from ages.

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