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Anti-Inflammatory and Anti-Arthritic Efficacy of Herbal Extracts: A Comprehensive Review

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Abstract

Inflammation and rheumatoid arthritis (RA) are complex physiological and pathological processes that significantly impact global health. While conventional treatments such as NSAIDs and disease-modifying anti-rheumatic drugs offer symptomatic relief, their long-term use is often associated with adverse effects. This review highlights the anti-inflammatory and anti-arthritic potential of various medicinal plants, emphasizing their bioactive constituents—such as flavonoids, alkaloids, terpenoids, and saponins—that modulate key inflammatory pathways including COX-2, NF-κB, and cytokine signaling. Numerous plant extracts, demonstrate significant efficacy in experimental models of inflammation and arthritis. The findings underscore the promise of phytochemicals as safer, multi-targeted alternatives for managing chronic inflammatory conditions and autoimmune disorders like RA.

Keywords: Anti-inflammatory, Anti-arthritic, Bioactive compounds, Medicinal plants.

Introduction

Inflammation is a complex biological response triggered by harmful stimuli such as pathogens, damaged cells, or irritants. While it serves as a protective mechanism, chronic inflammation is implicated in the pathogenesis of various diseases, including rheumatoid arthritis (RA), cardiovascular disorders, and neurodegenerative conditions (Medzhitov, 2008). RA is a systemic autoimmune disease characterized by persistent synovitis, joint destruction, and elevated levels of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6 (Smolen et al., 2016).Conventional therapies for RA, including non-steroidal anti-inflammatory drugs (NSAIDs) and disease-modifying anti-rheumatic drugs (DMARDs), provide symptomatic relief but are often associated with adverse effects and limited efficacy in modulating immune pathways (Singh et al., 2016). This has led to increased interest in plant-based therapeutics, which offer multi-targeted mechanisms and improved safety profiles. Medicinal plants are rich in bioactive compounds—such as flavonoids, alkaloids, terpenoids, and saponins—that exhibit anti-inflammatory and anti-arthritic properties by modulating molecular targets like cyclooxygenase-2 (COX-2), nuclear factor-kappa B (NF-κB), and pro-inflammatory cytokines (Calixto et al., 2004).

Several studies have demonstrated the efficacy of plant extracts such as *Boswellia serrata*, *Withaniasomnifera*, and *Ocimum sanctum* in experimental models of inflammation and arthritis (Ammon, 2006; Gupta et al., 2014). These findings highlight the therapeutic potential of phytochemicals as safer alternatives to conventional drugs and support their integration into modern treatment strategies for chronic inflammatory diseases.

This paper reviews the anti-inflammatory and anti-arthritic activities of selected medicinal plants, emphasizing their bioactive constituents, mechanisms of action, and relevance in contemporary pharmacotherapy.

Anti-inflammatory activities of medicinal plants

The body's principal physiological defense system against infection by bacteria, fungi, parasites and viruses, burns, toxic chemicals, allergies, and other harmful environmental stimuli is inflammation. Inflammatory mediators are implicated in aggravating or maintaining a bigger variety of diseases even though it is a protective mechanism (Sosa *et al.,*2002). Many of these chronic disorders, including RA, asthma, redness (from increased blood flow), swelling (from increased vascular permeability), pain (from sensitization of primary afferent nerve fibers), and others, may have uncontrolled and persistent inflammation as an etiologic factor (Levine and Reichlimg, 1999).

Modern medications have substantially benefited from the development of natural compounds, notably those produced from higher plants. According to Calixto *et al.,* (2003), the majority of secondary metabolites formed from plants are known to interfere either directly or indirectly with molecules such arachidonic acid, cytokines, prostaglandins, leukotrienes, cyclooxygenase (COX-2) and lipooxygenase. As a result, recent research on plant-derived chemicals with anti-inflammatory effects is highly active (Agnihotri *et al.,*2010). Methylsalicylate, an anti-inflammatory substance with prostaglandin inhibitory effect, was found in *Securidacalongipendunculata* roots (Costa, 1992). Methylsalicylate makes up roughly 90% of the volatile substance in the same plant's root extract(Jayasekara, 2002). 16.63% of linolenic acid is present in the *Ocimum sanctum* seeds, which have potent anti-inflammatory properties without being very harmful (Godhwani *et al.,*1987; Singh and Majumdar, 1997; Singh *et al.,*1996). Plant extracts of *Lactuca scariola* and *Artemisia absinthium* have anti-inflammatory properties (Ahmad *et al.,* 1992). The bioactive fraction extracted from the seeds of *Trigonella foenum-gracum*, roots of *Glycirrhiza glabra* and fruits of *Coriandrum sativum* have been reported to have anti-inflammatory properties (Ammar *et al.,* 1997).

Ursolic acid obtained from *Plantago major*inhibits the COX-2 enzyme(Ringbom*et al.,*1998; Subbaramaiah*et al.,*2000) andavicins, a triterpenoid saponin derived from *Acacia victoria*, have anti-inflammatory properties by reducing COX-2 production through inhibiting NF-KB(Sailer *et al.,* 1996; Haridas *et al.,* 2001). From *Helichrysum italicum*, Sala *et al.,* (2001) discovered a novel acetophenone glucoside with anti-inflammatory properties. By decreasing the formation of prostaglandin E 2, Platycodin D, which was isolated from the roots of *Platycodon grandiflorum*, displayed anti-inflammatory effect (Kim *et al.,*2001).Through inhibiting the release of pro-inflammatory mediators of acute inflammation like histamine and prostaglandin, *Securidacalongipedunculata* root bark extracts have been found to have potent anti-inflammatory effects in topical and systemic models of acute inflammation (Okoli *et al.,* 2005). Arul *et al.,* (2005) demonstrated the presence of anti-inflammatory properties in the aerial portions of *Coldenia procumbens*asit prevented the edema in carrageenan-induced rat paw swelling.

The water-soluble portion of an ethanolic extract of *Nyctanthes arbor-tristis* demonstrated efficacy against inflammation brought on by a foreign body (Tripathi *et*

*al.,*2011). Patel *et al.,* (2011) observed that *Trapa natans*' pericarp and seeds both exhibited anti-inflammatory effect in aqueous extracts, but the pericarp did so with greater potency. From the leaves of *Bauhinia variegata*, Saha et al. (2011) extracted a bioactive triterpene saponin that was found to have stronger anti-inflammatory effect in petroleum ether than ethanol. The ethanolic extract of *Calllicarpa macrophylla* leaves has a stronger anti-inflammatory profile than the aqueous extract, according to studies by Yadav et al. (2011), and may be the best option to be utilised as an anti-inflammatory medicine.

Anti arthritic activities of medicinal plants

Rheumatoid arthritis (RA) is a chronic, progressive auto-immune disease with an unknown etiology, meaning that instead of defending the joints by manufacturing the molecules that fight them, the body's immune system accidentally attacks healthy tissues. This condition affects about 1% of the world's population and affects women two to three times more frequently than men. Leukotrines, cytokines, and other pro-inflammatory indicators are present in rheumatoid arthritis. The main markers of inflammation are IL-1, TNF-, IL-6, and IL-15. IL-16. Pain, joint swelling, and joint injury are caused by IL-17, IL-18, IFN-, and granulocyte macrophage-colony stimulating factor, chemokines including IL-8, macrophage inflammatory protein-1, and monocyte chemo attractant protein-1.

According to Mayo (1988), *Actaea racemosa* contains tannin, salicylic acid, isoflavones, and 27-deoxyacetin, all of which are used to cure arthritis. Alkaloids, tannins, rutin, and stigmasterolswhich has anti -arthritic effect were found to be present in the *Uncaria tomentosa*(San doval*et al.,* 2002). Both *Colchicum luteum* and *Foniculum vulgare* have been shown to be effective in decreasing carrageenan-induced paw edema (Javed *et al.,*2005; Ozbek, 2005).Due to the presence of chemical components such as tannins, triterpenes, anthroquinones, flavonoids, saponins, and steroids, FCA-induced arthritic rats have shown antiarthritic effects (Narendhirakannan*et al.,* 2007).

In carrageenan-induced acute paw arthritis, piperine, an alkaloid derived from *Piper nigrum*, demonstrated anti-arthritic effect (Bang *et al.,*2009). *Abutilon indicum, Anisomelesmalabarica, Physalis angulata, Arissaema rhizomatum, Colchicum luteum* and*Centella asiatica* all showed anti-arthritic activity in their leaves (Deshpande *et al.,*2009; Chen *et al.,*2011; Nair *et al.,*2011). Due to the presence of alkaloids and steroidal lactones, oral treatment of *Withaniasomnifera* root powder has an anti-arthritic effect in adjuvant-induced arthritic rats (Mirjalili*et al.,*2009; Patwardhan *et al.,*2010). According to Joseph and Raj (2010), the anthroquinone complex, which includes anthracene, cinnamic acid, and anthranilic acid, is what gives *Aloe vera* its anti-arthritic benefits. By inhibiting COX-2, INF, and TNF in mice with arthritic joints, the powerful antioxidant epigallocatechin from the leaves of *Camellia sinensis* decreased collagen-induced arthritis (Chopade*et al.,*2008; Akroum*et al.,*2009; Ahmed, 2010).

According to Tripathy *et al.,* (2010), *Ammaniabaccifera* alcohol extract has anti-arthritic properties. The *Vitex negundo* petroleum ether extracts inhibited paw edema in 4 hours which is attributed to the presence of glycosidic iridoids and alkaloids in a dose-dependent manner in carrageenan-induced hind paw edema (Subramani *et al.,*2009; Vishwanathan *et*

*al.,*2010). In FCA-induced arthritis, long-term administration of *Premnacorymbosa* leaves dramatically reduced the onset of chronic arthritics (Karthikeyan and Deepa, 2010).

Triterpenoids, oleanolic acid, ursolic acid, beta-sitosterol, and diterpenes found in *Leucas aspera* have been shown to have anti-rheumatic properties in FCA-induced arthritis (Prajapathi *et al.,*2010; Kripa *et al.,*2010). Alkaloids, flavonoids, tannins, glycosides, steroids, and phenolic compounds found in *Premnaserratifolia* ethanolic extract have been shown to have anti-arthritic effect in rat paw edema (Rajendran, 2010). Oral administration of 200 mg/kg of *Cleome rutidosperma*'s ethanolic extract reduced FCA-induced rat paw edema by 44% (Chakraborty and Roy, 2010). According to Otari *et al.,* (2010), *Vernonia antihelmintica* seed ethanolic extract demonstrated a substantial anti-arthritic effect.

Cissampelos pareira's ethanolic root extract showed a dose-dependent protective effect against FCA-induced arthritis (Amresh *et al.,*2007). At a dose of 200 mg/kg, the bark of *Terminalia paniculata* demonstrated anti-rheumatic action (Talwar *et al.,*2011). *Ficus bengalensis* bark extract in methanol was tested for anti-rheumatic activity utilizing a variety of arthritis-induced animals (Joseph & Raj, 2011; Manocha *et al.,*2011). The findings suggested that flavonoids, tannins, saponins, and steroids may contribute to the plant's anti-rheumatic activity as well as its ability to alter the auto immune system.

According to Behbahani *et al.,* (2007) and Patil *et al.,* (2011), bartogenic acid in *Barringtonia racemosa* appears to be the active ingredient responsible for the plant's anti-arthritic effect. At a dose of 100 mg/kg, the tinosporine, tinosporide, cordifolide, columbin, and b-sitosterol in *Tinospora cordifolia* reduced the size of the paw in rats with collagen-induced arthritis (Jana *et al.,*1999; Singh *et al.,*2003; Rawal *et al.,*2009; Paval *et al.,*2011). Chandur*et al.,* (2011) reported that *Saussurealappa* root extracts have potent anti-arthritic properties.

Presence of triptolide, *Tripterygium wilfordii* extract reduced the number of arthritic joints, the severity of the arthritis, and the titers of anticollagen antibodies in mice with type II collagen-induced arthritis (Kimura *et al.,*2011). By virtue of its phyto components, the methanolic extract of *Saracaasoca* decreased the thickness of the paws in rats given an adjuvant to cause arthritis (Saravanan *et al.,*2011). The ability of *Glycyrrhiza glabra* and *Boswellia serrata* to stabilize lysosomal enzyme activity, such as ACP, and the considerable reduction in paw edema volume were used to measure their anti-arthritic effects (Mishra *et al.,*2011). The findings of Khan *et al.,* (2011) suggested that the commercially available drug Methotrexate is less effective than the herbal medication arthritin, which is produced from seven different herbs (Rehman *et al.,*2011). Sesquiterpene lactones from *Zingiber officinale* were discovered to be an anti-arthritic substance. At a dose of 180 mg/kg, the roots of *Calotropis procera* exhibited anti-inflammatory action (Babu and Karki, 2011). The anti-arthritic property of the leaves of *Nyctanthesarbortristis* was due to the presence of nycthanic acid, b- amyrin, and b- sitosterol (Bhalerao *et al.,*2011; Sandhar *et al.,*2011). According to chemical analyses of *Justicia gendarussa* aerial parts, -sitosterol, aromadendrin, flavonoids, and vitexin were found to have anti-arthritic activity in large amounts (Paval et al., 2009a, b; Bachhet*iet al.,*2011; Correa and Silva,2012).

Coumarin, tannic acid, triterpenoid, and saponins of *Hemidesmus indicus* reduced paw volume and thickness more than *Diclofenac sodium* (Rajan *et al.,*2012). Due to its modulatory

influence on the expression of proinflammatory cytokines in the synovium, the hydroalcoholic extract of *Terminalia chebula* demonstrates anti-arthritic activity (Nair *et al.,*2010; Singh and Sharma, 2010; Chang and Lin, 2012). The regulation of proinflammatory cytokines in the synovium may be responsible for the anti-arthritic effect of *Coriandrum sativum* hydroalcoholic extracts (Nair *et al.,*2012).

The daily oral treatment of various dosages of *Randia dumetorum* methanolic extract to CFA rats reduced paw edema and the arthritic index, making this plant an excellent option for further RA study (Patel et al., 2012). The leaves of *Cocculus hirsutus*, *Barlerialupulina, Barringtonia acutangula, Tribulus terrestris*and the roots of*Litsea cubeba* have all been found to have anti-arthritic properties (Mazumder et al., 2012; Thirumal et al., 2013; Mishra and Biswal, 2013).

Due to the presence of flavonoids, steroids, and phenols, the ethanolic extract of *Caesalpinia pulcherrima* at two different doses (200 and 400 mg kg-1) have demonstrated anti-arthritic activity with a significant decrease in paw volume in the FCA-induced arthritic rat model (Rajaram *et al.,*2015).Thus the review clearly demonstrated that plant are a rich source of bioactive compounds which has both anti-inflammatory and anti-arthritic properties,

Conclusion

The comprehensive review of medicinal plants with anti-inflammatory and anti-arthritic properties underscores the therapeutic potential of phytochemicals in managing chronic inflammatory conditions such as rheumatoid arthritis. Numerous plant extractshave demonstrated significant efficacy in experimental models by modulating key inflammatory mediators such as COX-2, NF-κB, TNF-α, and IL-1β. Bioactive compounds, including flavonoids, alkaloids, terpenoids and saponins, offer multi-targeted mechanisms with fewer adverse effects compared to conventional drugs. The evidence presented supports the integration of plant-based therapeutics into modern pharmacological strategies, especially for autoimmune and inflammatory disorders.

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