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Medicinal plants in the management of autoimmune diseases

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Abstract

Autoimmune diseases (AIDs) are characterized by dysregulated immune responses where the body's immune system mistakenly attacks its own tissues, leading to chronic inflammation and tissue damage. The rising prevalence of AIDs such as rheumatoid arthritis, multiple sclerosis, systemic lupus erythematosus, and type 1 diabetes has sparked interest in complementary and alternative therapies, particularly medicinal plants. This review explores the role of medicinal plants in the management of autoimmune diseases, focusing on their Immunomodulatory, anti-inflammatory, and antioxidant properties. We will examine the bioactive compounds in key plants such as *Curcuma longa* (turmeric), *Withania somnifera* (ashwagandha), *Boswellia serrata* (Indian frankincense), and *Glycyrrhiza glabra* (licorice), along with the mechanisms through which these compounds modulate immune responses. By evaluating clinical studies and ethnopharmacological data, we aim to provide a comprehensive understanding of the potential of medicinal plants in AID management.

Keywords: AID management, autoimmune diseases, medicinal plants, management

1. Introduction

Autoimmune diseases (AIDs) affect millions of people worldwide, and their incidence has been rising over the last few decades. These diseases occur when the immune system, which normally protects the body against infections, erroneously targets the body's tissues. The exact causes of AIDs remain unknown, but genetic predisposition, environmental triggers, and hormonal influences are known to play roles. Conventional treatments for AIDs often involve immunosuppressive drugs that aim to reduce immune system activity. While effective, these treatments can have severe side effects and leave patients vulnerable to infections ^[1]. Therefore, medicinal plants have gained attention as complementary therapies due to their perceived safety, long-standing historical use, and potential to balance immune responses. This review focuses on several key medicinal plants, including *Curcuma longa* (turmeric), *Withania somnifera* (ashwagandha), *Boswellia serrata* (Indian frankincense), and *Glycyrrhiza glabra* (licorice), all of which possess Immunomodulatory and anti-inflammatory properties that may offer therapeutic benefits in managing autoimmune diseases.

2. Main Objective

The main objective of this paper is to explore the potential of medicinal plants in managing autoimmune diseases through their Immunomodulatory, anti-inflammatory, and antioxidant properties.

3. Pathophysiology of Autoimmune Diseases

Understanding the underlying mechanisms of AIDs is crucial to explore how medicinal plants can help in their management. AIDs arise from a failure of self-tolerance, leading to the activation of auto reactive T and B cells ^[2]. The overproduction of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and interferon-gamma (IFN- γ) plays a key role in the progression of these diseases. This dysregulation results in chronic inflammation and the destruction of healthy tissues, which manifests in a range of clinical symptoms depending on the target organ or system. While conventional therapies aim to reduce inflammation and suppress immune responses, their long-term use can lead to adverse effects, including immunosuppression and toxicity.

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4. Role of Medicinal Plants in Autoimmune Disease Management

4.1 *Curcuma longa* (Turmeric)

Turmeric is widely known for its anti-inflammatory and Immunomodulatory properties, primarily due to the active compound curcumin. Curcumin has been shown to inhibit the production of pro-inflammatory cytokines, including TNF- α and IL-6, and reduce the activation of nuclear factor kappa-light-chain-enhancer of activated B cells (NF- κ B), a key player in immune responses. Studies have demonstrated the efficacy of curcumin in reducing symptoms in patients with rheumatoid arthritis (RA) and inflammatory bowel disease (IBD). In preclinical models, curcumin was found to suppress autoimmune responses by modulating the function of T cells and inhibiting the differentiation of Th1 and Th17 cells, which are involved in AID pathogenesis [3].

4.2 *Withania somnifera* (Ashwagandha)

Ashwagandha is an adaptogen commonly used in Ayurvedic medicine to reduce stress and improve immune function. The bioactive compounds in ashwagandha, known as withanolides, have demonstrated anti-inflammatory, immunosuppressive, and antioxidant activities. In AIDs like multiple sclerosis (MS) and systemic lupus erythematosus (SLE), where oxidative stress plays a crucial role, ashwagandha has shown potential in reducing inflammation and preventing further tissue damage. Studies have reported that ashwagandha suppresses the activation of macrophages and T cells, reducing the levels of pro-inflammatory cytokines while promoting the proliferation of regulatory T cells (Tregs), which are critical in maintaining immune homeostasis [5].

4.3 *Boswellia serrata* (Indian Frankincense)

The resin of *Boswellia serrata* contains boswellic acids, which possess potent anti-inflammatory properties. Boswellic acids act by inhibiting 5-lipoxygenase, an enzyme involved in the synthesis of leukotrienes, which are mediators of inflammation in autoimmune conditions. Clinical trials have shown that boswellia extracts are effective in treating RA, osteoarthritis, and ulcerative colitis. Additionally, boswellia has been found to reduce joint swelling and pain in RA patients, offering a natural alternative or complementary option to conventional anti-inflammatory drugs [4].

4.4 *Glycyrrhiza glabra* (Licorice)

Licorice has been used in traditional medicine for centuries due to its anti-inflammatory and immune-boosting properties. The active compound glycyrrhizin exerts Immunomodulatory effects by modulating the activity of macrophages and dendritic cells, which are pivotal in orchestrating immune responses. In autoimmune conditions like lupus and RA, glycyrrhizin inhibits the production of reactive oxygen species (ROS) and suppresses the proliferation of auto reactive lymphocytes. By down regulating pro-inflammatory cytokines such as IL-1 β , IL-6, and TNF- α , licorice helps to restore immune balance and reduce the inflammatory burden in AIDs [7].

5. Mechanisms of Action: How Medicinal Plants Modulate the Immune System

Medicinal plants modulate the immune system through a variety of complex mechanisms, primarily targeting the regulation of immune cell function, cytokine production, and oxidative stress pathways. These plants contain bioactive

compounds that influence both innate and adaptive immunity, resulting in therapeutic effects for autoimmune diseases. Relevant studies highlight that many medicinal plants work by modulating the inflammatory response, which is a key feature in the pathogenesis of autoimmune diseases [6]. One of the primary mechanisms through which medicinal plants modulate the immune system is by regulating the production of pro-inflammatory cytokines. In autoimmune diseases, cytokines such as tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and interferon-gamma (IFN- γ) are often overproduced, leading to chronic inflammation and tissue damage. Medicinal plants like *Curcuma longa* (turmeric) have been extensively studied for their ability to inhibit the activation of nuclear factor kappa B (NF- κ B), a transcription factor responsible for the expression of pro-inflammatory cytokines. Studies on curcumin, the active component of turmeric, have demonstrated its capacity to down regulate TNF- α and IL-6, reducing inflammation and immune activation in conditions such as rheumatoid arthritis and inflammatory bowel disease. Similar effects have been observed with other plants like *Boswellia serrata* and *Withania somnifera*, which reduce the levels of inflammatory mediators and promote an anti-inflammatory environment. Another critical mechanism is the suppression of immune cell activation and proliferation. In autoimmune diseases, overactive T and B lymphocytes contribute to the autoimmune response by attacking the body's own tissues. Certain medicinal plants have been shown to modulate the activity of these cells, preventing their over activation. For example, ashwagandha (*Withania somnifera*) has demonstrated the ability to suppress T-cell proliferation and inhibit macrophage activation, which are both important steps in the autoimmune process. Furthermore, glycyrrhizin from licorice (*Glycyrrhiza glabra*) has been reported to modulate dendritic cell activity, influencing the antigen-presenting process and dampening the immune system's tendency to react aggressively [8]. In addition to modulating cytokine production and immune cell activation, medicinal plants also promote the activity of regulatory immune cells that help maintain immune tolerance. Regulatory T cells (Tregs) play a key role in preventing the immune system from attacking healthy tissues by maintaining self-tolerance. Studies have shown that medicinal plants such as ashwagandha enhance Treg activity, thus promoting immune homeostasis and preventing autoimmune flare-ups. The promotion of Treg function is especially important in diseases such as systemic lupus erythematosus (SLE) and multiple sclerosis, where self-tolerance is severely compromised. Oxidative stress is another contributor to the pathogenesis of autoimmune diseases. Excessive production of reactive oxygen species (ROS) leads to tissue damage and exacerbates the inflammatory response. Many medicinal plants, including turmeric and boswellia, possess strong antioxidant properties that neutralize ROS, thereby reducing oxidative stress and preventing further tissue damage. Curcumin, for example, has been shown to scavenge free radicals and enhance the expression of antioxidant enzymes like superoxide dismutase (SOD) and catalase. By mitigating oxidative damage, medicinal plants help protect tissues from the long-term effects of chronic inflammation [9]. Furthermore, studies suggest that medicinal plants modulate key signaling pathways involved in immune responses. The mitogen-activated protein kinase (MAPK) and Janus kinase-signal transducer and activator of transcription (JAK-STAT) pathways are critical in regulating immune cell activation and cytokine production. Certain plant compounds, such as

boswellic acids from boswellia, have been found to inhibit these pathways, thereby reducing inflammatory signaling and immune over activation.

In summary, medicinal plants modulate the immune system through a combination of mechanisms, including the inhibition of pro-inflammatory cytokines, suppression of immune cell activation, promotion of regulatory immune cells, reduction of oxidative stress, and modulation of key immune signaling pathways. These effects, supported by extensive studies, highlight the therapeutic potential of medicinal plants in managing autoimmune diseases, offering a complementary approach to conventional immunosuppressive therapies.

6. Clinical Evidence and Ethnopharmacology

Clinical evidence supporting the use of medicinal plants in the management of autoimmune diseases has been growing, with numerous studies demonstrating their effectiveness in reducing symptoms and improving patient outcomes. Medicinal plants such as *Curcuma longa* (turmeric), *Withania somnifera* (ashwagandha), *Boswellia serrata* (Indian frankincense), and *Glycyrrhiza glabra* (licorice) have been investigated in clinical trials for their Immunomodulatory, anti-inflammatory, and antioxidant properties, all of which are relevant to the treatment of autoimmune diseases^[10].

In a clinical study on rheumatoid arthritis (RA) patients, curcumin from *Curcuma longa* was found to significantly reduce joint swelling and pain. The study demonstrated that curcumin was as effective as non-steroidal anti-inflammatory drugs (NSAIDs) in alleviating symptoms but with fewer side effects, making it a promising alternative for long-term management of autoimmune conditions. Additionally, curcumin's ability to downregulate pro-inflammatory cytokines such as TNF- α and IL-6 was highlighted as a key factor in its therapeutic efficacy. Other clinical trials have shown that curcumin improves outcomes in patients with inflammatory bowel disease (IBD), including ulcerative colitis and Crohn's disease, suggesting broad-spectrum benefits across different autoimmune diseases.

Withania somnifera (ashwagandha) has been widely used in traditional medicine for its adaptogenic and Immunomodulatory properties. Clinical trials on patients with multiple sclerosis (MS) have shown that ashwagandha helps reduce fatigue, improve mobility, and enhance overall quality of life. Its ability to promote the activity of regulatory T cells (Tregs) and reduce oxidative stress has been proposed as the underlying mechanism for these benefits. In traditional Ayurvedic medicine, ashwagandha has long been used to treat conditions associated with immune dysfunction and chronic inflammation, and modern clinical studies have started to validate these ethnopharmacological uses.

Boswellia serrata (Indian frankincense) has demonstrated clinical efficacy in reducing inflammation and pain in autoimmune conditions like RA, osteoarthritis, and ulcerative colitis. A randomized controlled trial conducted on RA patients revealed that boswellic acids, the active compounds in boswellia, significantly reduced joint pain and swelling, and improved physical function. Moreover, the anti-inflammatory effects of boswellia have been attributed to its ability to inhibit 5-lipoxygenase, an enzyme involved in the synthesis of leukotrienes, which are key mediators of inflammation. The long history of boswellia in traditional medicine for treating arthritis and gastrointestinal diseases has been supported by these clinical findings. *Glycyrrhiza glabra* (licorice) has also been studied for its potential in treating

autoimmune diseases, particularly due to its anti-inflammatory and immune-modulating effects. Clinical studies on licorice have focused on its ability to reduce inflammation in patients with systemic lupus erythematosus (SLE) and rheumatoid arthritis. Glycyrrhizin, the active compound in licorice, has been shown to inhibit macrophage activity and reduce the levels of pro-inflammatory cytokines such as IL-1 β and TNF- α . Traditional Chinese Medicine has utilized licorice in formulations for centuries, and its inclusion in modern clinical trials validates its historical ethnopharmacological use in treating conditions marked by chronic inflammation and immune dysregulation.

Ethnopharmacology, the study of the traditional use of plants by indigenous cultures, has provided valuable insights into the therapeutic potential of medicinal plants for autoimmune diseases. Many of the plants discussed in this review have been used for centuries in traditional medical systems such as Ayurveda, Traditional Chinese Medicine (TCM), and Indigenous African Medicine to treat inflammatory and immune-related disorders. These systems often emphasize holistic approaches that aim to restore balance in the body, aligning with the concept of Immunomodulation.

For example, Ayurvedic medicine has long recognized *Curcuma longa* as a potent anti-inflammatory agent used to treat conditions like arthritis and digestive disorders, which are now understood to have autoimmune components. Similarly, ashwagandha has been used in Ayurveda for its stress-relieving and immune-boosting properties, aligning with modern understandings of how stress impacts immune function in autoimmune diseases. In TCM, licorice is used to "harmonize" formulations, enhancing the effects of other herbs and reducing toxicity, a practice supported by modern studies showing licorice's ability to modulate immune responses and protect against oxidative stress.

The integration of clinical evidence with ethnopharmacological knowledge underscores the potential of medicinal plants in managing autoimmune diseases. While traditional uses have often guided the selection of plants for modern clinical studies, these studies, in turn, help validate and refine ethnopharmacological practices, offering a scientific basis for the continued use of medicinal plants in autoimmune disease management.

7. Conclusion

This review highlights the potential of medicinal plants as complementary therapies in the management of autoimmune diseases. Plants such as *Curcuma longa* (turmeric), *Withania somnifera* (ashwagandha), *Boswellia serrata* (Indian frankincense), and *Glycyrrhiza glabra* (licorice) demonstrate significant Immunomodulatory, anti-inflammatory, and antioxidant properties, supported by both clinical evidence and ethnopharmacological knowledge. These medicinal plants can modulate key immune processes by reducing pro-inflammatory cytokine production, suppressing immune cell over activation, enhancing regulatory T cell function, and mitigating oxidative stress, thus offering therapeutic benefits for conditions like rheumatoid arthritis, multiple sclerosis, and systemic lupus erythematosus.

While promising, further research is needed to establish standardized dosages, ensure safety, and explore potential interactions with conventional treatments. Nevertheless, medicinal plants offer a valuable, natural approach to managing autoimmune diseases, with the potential to reduce dependence on immunosuppressive drugs and their associated side effects. Their integration into healthcare could provide

patients with safer, more holistic options for long-term disease management.

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