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REVIEW ARTICLE **OPEN ACCESS**

Prospective Anti-Inflammatory Medicinal Plants - A Review

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ABSTRACT
Inflammation is a vital process in the development of various diseases, serving as a natural defense mechanism against tissue damage and infections. It seeks to heal injured tissues and is distinguished by indications like swelling, heightened pain sensitivity (hyperalgesia), heat and redness. These symptoms are driven by inflammatory agents like histamine, prostaglandins, bradykinin, serotonin, leukotrienes, and nitric oxide. NSAIDs are commonly employed for relieve Discomfort and swelling. However, research has shown that NSAIDs may contribute to cardiovascular events like myocardial infarction, and heart failure, as well as stroke, Despite advancements in inflammation treatments, the adverse effects of NSAIDs limit their use. Natural sources provide various chemical categories of anti-inflammatory agents, including saponins, terpenoids, alkaloids, anthraquinones, flavonoids, lignans, polysaccharides, polyphenols, and peptides. Within this range flavonoids have emerged as prominent anti-inflammatory agents. This summary highlights the advantages of herbal medicine over NSAIDs. Herbal remedies have a lower risk of adverse effects compared to synthetic drugs, making them an attractive option for those seeking gentle and natural alternatives. Herbal medicine has gained renewed attention for complementing modern medical approaches, offering personalized and holistic healthcare solutions that align with individuals' pursuit of balance and harmony in their health journeys. This review focuses on better understanding the therapeutic potential of herbal remedies and making informed healthcare decisions.
Keywords: *Inflammation, NSAIDs, Inflammatory mediators, Herbal medicine*

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INTRODUCTION

The word "inflammation" originates from the word "inflammare," that means "to burn" (de Oliveira) [1]. It is a common phenomena that happens after severe homeostasis disturbances instances of infection, physical injury, and exposure to harmful substances and is activated by innate immune receptors that recognize pathogens and wounded cells [2]. It's a natural reaction that defends our body from microbial invasion or tissue injury. The aim of the inflammatory reaction is to promote any injured or infected tissue [3]. When natural physiological processes within the body are not effectively coordinated, they can lose their ability to resolve as intended, ultimately leading to the emergence and development of various diseases. These health conditions include a broad spectrum, including asthma, inflammatory bowel disease, rheumatoid arthritis, obesity, atherosclerosis, cancer, type 2 diabetes, and neurodegenerative disorders such as multiple sclerosis, Alzheimer, and Parkinson [4]. The process of inflammation can be described as a series of highly coordinated and dynamic responses that encompass both cellular and vascular processes, accompanied by the secretion of humoral substances that are spacific. These pathways involve the systematic movement of various white blood cell (WBC) types, including monocytes, basophils, eosinophils, and neutrophils, as well as the redistribution of plasma and fluids to the swollen site. Additionally, a group of signaling molecules and secreted mediators, such as oxygen- and nitrogen-derived free radicals, leukotrienes, serotonin, prostaglandins, and are histamine released primarily by immune defense cells [1]. Inflammatory pathway depends primarily on these inflammatory mediators. This results in the enlargement of surrounding blood vessels, a decrease in blood flow, and an increase in vascular permeability, which allows neutrophils and plasma proteins to leak into the affected tissue. This inflammatory response ultimately leads to the manifestation of symptoms like redness, swelling, heat, and pain, all of which contribute positively to pathogen eradication, infection containment, and tissue repair [5]. There exist two primary categories of inflammation:

1. Acute inflammation
2. Chronic inflammation

Acute inflammation is a transient condition that may arise due to hazardous substances, microbial invasion, or tissue damage. It initiates rapidly, progresses rapidly, and symptoms may endure for a brief period, such as in cases of cellulitis or acute pneumonia [6]. Acute inflammation is characterized by heightened vascular permeability, capillary infiltration, and the migration of leukocytes [7].

Subacute inflammation represents the phase that bridges the gap between acute and chronic inflammation and typically lasts from 2 to 6 weeks [6].

Chronic inflammation is a term used to describe chronic, long-term inflammation that lasts for prolonged duration of time, often up to years. Broadly speaking, The source of the injury and the body's ability to heal and recover from it determine the degree and length of chronic inflammation [6]. After an inflammatory event, the goal is to rapidly and completely remove these leukocytes from the damaged area [8]. It is characterized by fibroblast activation, proliferation (angiogenesis), and the formation of fibrosis, as well as the infiltration of mononuclear immune cells, such as neutrophils, and macrophages [7]. Chronic inflammatory diseases are identified as a primary cause of mortality, responsible for the deaths over 50% related to conditions such as cancer, diabetes, non-alcoholic fatty liver disease (NAFLD) and ischemic heart disease [9]. Inflammatory reactions of various kinds result in the synthesis and secretion of a large number of inflammatory mediators. Pro- and anti-inflammatory mediators are the two basic divisions of inflammatory chemicals. The pro- and anti-inflammatory qualities of certain mediators, such as interleukin (IL)-12, are still present. Several cellular pathways and inflammatory mediators have been thoroughly studied in human pathological conditions. These include interleukins, tumor necrosis factor, eicosanoids (such as prostaglandins and leukotrienes), interferons, chemokines (such as monocyte chemoattractant protein), the powerful inflammation-modulating transcription factor nuclear factor B [10]. Cytokines are compact proteins that have a crucial role in initiating and sustaining inflammation, while simultaneously controlling both the intensity and length of the response. [8]. Consequently, they form a category of immunoregulatory molecules. These cytokines work in tandem with specific cytokine inhibitors and soluble cytokine receptors to finely regulate the human immune system. Their function in regular physiological inflammation and their involvement in pathological conditions characterized by systemic inflammation have gained increasing recognition. Key anti-inflammatory cytokines encompass interleukin (IL)-1 receptor antagonists, IL-4, IL-6, IL-10, IL-11, and IL-13. Furthermore, certain cytokine receptors designed for IL-1, tumor necrosis factor-alpha, and IL-18 also serve as inhibitors of proinflammatory cytokine [11]. NSAIDs rank highly as some of the most frequently utilized medications to manage fever and discomfort [5]. The dual actions of NSAIDs are to reduce inflammation and act as painkillers. They function by preventing prostaglandins, which are molecules that induce pain and inflammation, from being produced by the body [12]. Efforts aimed at managing inflammation have primarily concentrated on utilization of pharmaceutical agents that impede pro-inflammatory mediator pathways. Their anti-inflammatory mechanism primarily involves the inhibition of cyclooxygenase (COX), which results in a reduction of prostaglandin production, a key inflammatory mediator [5]. Recent classes of inhibitors are designed to affect lipoxygenase pathways and the production of leukotrienes (LT), or they target TNFα [8]. It is widely recognized that current analgesic drugs, including opiates and NSAIDs, may not be universally effective due to their associated side effects, such as gastrointestinal irritation and liver dysfunction, among others. Several immunosuppressive agents have been developed based on their COX-1 inhibition mechanism, but their prolonged use often results in severe negative effects side. Consequently, selective COX-2 inhibitors were created to mitigate adverse outcomes associated with COX-1 inhibitors [7]. However, subsequent studies have revealed that these drugs can also be associated with adverse cardiovascular events, such as stroke, myocardial infarction, and gastrointestinal (GI) complications as well as heart failure, [4]. Plants are considered the fundamental source of life on our planet and are essential resources for both humans and animals. Ensuring the safety, quality, and effectiveness of therapeutic plants and natural goods used by individuals is a top priority in both developed and developing nations. The therapeutic qualities of plant material are determined by the active components it contains [13]. Many diseases have been treated using medicinal plants since the earliest days of human civilization [14]. Traditional medicine relieson expertise, techniques, and practices aimed at preserving and enhancing physical well-being. It is employed for both *in-vivo* and *in-vitro* research, encompassing the utilization of plants, animals, and various methods in its practice [15]. Most of the medications used in clinical practice to treat infectious diseases, along with malignancies of various sources are derived from plants with medicinal properties and their synthetic and semi-synthetic derivatives [16]. Plants are abundant in bioactive secondary metabolites, such as alkaloids, tannins, polyphenolic, flavonoids, saponins, pro anthocyanidin, terpenoids, and terpenoids [3],[17]. These compounds are further classified as antioxidants, analgesics, cardioactive agents, anticancer agents, immunity enhancers, detoxifiers,

neuropharmacological agents, and more, depending on their pharmacological effects. Consequently, plants with established traditional medicinal value, substantiated by scientific evidence, have opened up avenues for the discovery of numerous potential therapeutic drugs [5]. The relevance of natural products and chemicals produced from them used to develop novel medications has led to an increase in study on these topics in recent years [17].

S.No.	Plant	Family	Part of plant used	Phytoconstituents	Reference
1.	Zingiber officinale	Zingiberaceae	Root	Gingerols, shogaols, Paradols, zingirone	[18]
2.	Curcuma longa	Zingiberaceae	Root, rhizome	Curcumin, bisdemethoxycurcumin, demethoxycurcumin	[19]
3.	Oroxylum indicum	Bignoniaceae	Leaf, root, bark	Flavanoids, baicalein glycocids, benzoic acid & fatty acids	[20]
4.	Tricodesma indicum	Boraginaceae	Leaf, flower, root	Flavonoids, terpenoids & steroids	[21]
5.	Vitex negundo	Verbenaceae	Leaf, root, seed, fruit	Terpinoids, polyphenols	[22]
6.	Nigella sativa	Ranunculaceae	Seed	Thymoquinone, vitamin E, calcium, Fe, omega 3	[23]
7.	Moringa oleifera	Moringaceae	Root, bark, leaves, seeds, flower	Flavonoids, alkaloids, tennins, cardiac glycosides	[24]
8.	Hibiscus rosa	Malvaceae	Flower,	Carbohydrates, proteins, flavonoids, alkaloids	[25]
9.	Ficus caria	Moraceae	Root, Fruit,	linolic acid, Alkaloids, caffeic acid, ascorbic acid, niacin,	[26]
10.	Acacia catechu	Mimosaceae	Flowering tops, bark, gum, Wood,	Catechuic acid, Gum, Tannin,	[26]
11.	Urticadioia	Urticaceae	Arial	Carotene, xanthophil, Tannins, flavonoid, cumarin, tannins, polysaccharids, malic acids	[27]
12.	Glycyrrhiza glabra	Fabaceae	Root	Terpinoids, flavons, chalcones, iso flavons, polysaccharides	[28]
13.	Agrimonia eupatoria	Rosaceae	Aerial	Polyphenol,	[29]
14.	Achilla whilhelmisii	Asteraceae	Aerial	Phenolic	[30]
15.	Ehretia acuminate	Boraginaceae	Bark	Alkaloids, glycosides, flavonoids	[31]
16.	Night arbortristis	Oleaceae	Leaf	Iridoid, glycosides, polyphenols	[32]
17.	Berberis lycium	Berberidaceae	Root	Alkaloid, isoquinoline, alkaloids	[33]
18.	Rubia cordifolia	Rubiaceae	Root	Terpinoids, iridoid	[34]
19.	Trigonella foenum-graecum linn	Legumes	Seed	Flavonoids, alkaloids, saponins, carbohydrates, vitamins	[35]
20.	Clitoriaternatea	Fabaceae	Root, flower, stem	Alkaloids, tannins, glycosides, resins, steroids, saponin, flavonoids, phenol terpines	[36]

Table 1: Plants that possess anti-inflammatory activity

DISCUSSION

Organic substances are still a major source for current medication research, encompassing various classes of compounds such as alkaloids (like morphine, camptothecin and galantamine), polyphenols (like icariin, epigallocatechin-3-gallate, resveratrol, and curcumin), and terpenoids (like, artemisinin, paclitaxel, and triptolide). These natural compounds have shown therapeutic potential in drug development [5]. Inflammatory cascade is maintained by several bio cascade that collectively work together. Pure compounds and natural extracts derived from plants have played a crucial role in addressing these mediators, leading to the exploration of innovative therapeutic approaches [4]. The primary focus of anti-inflammatory action involves the inhibition of enzymes responsible for producing eicosanoids, which encompass phospholipase A2, cyclooxygenases (COXs), and lipoxygenases. This inhibition results in a decrease in prostanoids and leukotrienes. Additionally, other mechanisms of anti-inflammatory effects include the suppression of histamine release, interference with phosphodiesterase, modulation of protein

kinases, and activation of transcriptases. [3] Flavonoids play a significant role as anti-inflammatory agents. Some of these compounds function as inhibitors of phospholipase, while various inflammatory conditions has been reported to inhibit TNF-α. Biochemical studies have further demonstrated that flavonoids modulate both the cyclooxygenase and lipoxygenase pathways of arachidonic acid metabolism, with the specific effects depending on their chemical structures [7],[21]. They classified into different subgroups, including flavonols, flavones, catechins, flavanones, anthocyanidins, and isoflavonoids [37]. Various flavonoids with calming properties have been found in therapeutic plants local to Brazil. For example, myricitrin and myricetin were confined from the Campomanesia adamantium (Cambess.) leaves, which has a place with the Myrtaceae family. Furthermore, luteolin and quercetin were distinguished in Achyrocline satureioides, a plant from the Asteraceae family [38]. Terpenoids, derived from isoprene, are challenging to synthesize chemically and they have gained significant attention because of their varied biological actions, including antioxidant, antiviral, anti-cancer, and effective anti-inflammatory properties [5]. Terpenoids, compounds with well-documented anti-inflammatory properties found in various therapeutic plants, have been widely described in the literature. These anti-inflammatory effects are often attributed to lupine-type triterpenes, which can reduce prostaglandin (PGE2) and nitric oxide (NO) synthesis [38]. Polyphenols exhibit diverse pharmacological and medicinal properties, such as antioxidant and anti-inflammatory effects, making them valuable tools for managing autoimmune disorders like vitiligo, ulcerative colitis, and multiple sclerosis. These compounds activate various intracellular pathways, including those involved in the immune response regulation, providing potential for pharmaceutical applications [39].Tannins are acknowledged for their capacity to expedite the wounds healing and irritated mucous membranes [40]. Pressing demand for novel therapeutic compounds that offer enhanced effectiveness and reduced side effects has generated significant interest in medicinal plants possessing anti-inflammatory properties [3]. For example one such study demonstrated the anti-inflammatory effects of Curcuma longa (turmeric) extract through modulation of pro-inflammatory cytokines and pathways [41]. Similarly, showcased the anti-inflammatory properties of Boswellia serrata (frankincense) extract, underscoring its ability to decrease inflammatory markers like TNF-α and IL-6 [42].

CONCLUSION

In conclusion, India's prominence as a leading global producer of medicinal plants underscores the significance of herbal resources in addressing diverse health conditions, owing to their safety, cost-effectiveness, and potential as innovative treatments [45]. Natural herbs offer a compelling alternative to synthetic anti-inflammatory agents, with phytoconstituents mirroring the mechanisms of synthetic compounds [46]. Robust research consistently showcases their ability to modulate inflammation through diverse mechanisms, providing promising avenues for the development of natural, plant-based anti-inflammatory therapies. These medicinal plants include phytoconstituents that can both prevent and cure undesired inflammatory diseases, including steroids, flavonoids, alkaloids, polysaccharides, terpenoids, tri-terpenoids, cinnamic acid, fatty acids, phenolics, and glycosides [46],[45]. Recognizing their potential to alleviate inflammation while minimizing side effects, herbal plant extracts merit further exploration and consideration as valuable components of integrative medicine and pharmaceutical research. Medicinal plants and their constituents offer qualities such as potency, accessibility, cost-effectiveness, safety and efficiency when compared to synthetic alternatives [46]. For instance, studies have highlighted the anti-inflammatory properties of *Curcuma longa* (turmeric) extract, *Boswellia serrata* (frankincense) extract and *Panax ginseng* extract, among others [41],[42],[43]. Furthermore, Numerous studies have collectively validated anti-inflammatory activities of various herbal plant extracts, such as *Camellia sinensis* (green tea), *Zingiber officinale* (ginger), and *Salvia miltiorrhiza* (Danshen) [39]. The focus of future research should prioritize the exploration of molecular mechanisms responsible for the diverse therapeutic applications of these therapeutic plants in the treatment of multiple diseases. Current reviews of patents related to both anti-inflammatory drugs and herbal plants offer valuable insights into the recent status and potential developments in this field [46].

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