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A Review On Phytochemical and Anti Inflammatory Activity of Plant Extract

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ABSTRACT

In the last few years, the journey through plant products as a major source of anti-inflammatory agents have caught attention in biomedical researches.Plant extracts have emerged as promising candidates due to their rich phytochemical composition and traditional medicinal uses. This literature review aims to synthesize current knowledge on the anti-inflammatory properties of plant extracts, focusing on their mechanisms of action, bioactive constituents, and therapeutic potentials. The review systematically examines findings from experimental studies and clinical trials, highlighting the diversity of plant sources and their efficacy in modulating inflammatory pathways. Additionally, challenges such as standardization of extracts and variability in bioactivity are discussed, emphasizing the need for detailed scientific validation to translate these findings into clinical applications. Overall, this review explains the potential of plant extracts as valuable resources for developing novel anti-inflammatory therapies, while proving for further research to elucidate their full therapeutic benefits.

KEYWORDS: Anti-inflammatory agents, phytochemical composition, plant extract, clinical trials

I. INTRODUCTION

Inflammation is defined as a normal defensive response of living tissues to injury caused by physical trauma, noxious chemicals, microbiological agents .as well as to remove the consequent necrosis cell and tissues. Inflammatory mediators are also released in allergic asthma, which is accompanied by inflammation of the airways with increased numbers of inflammatory cells accumulating in the alveolar submucosa. Release of mediators from these cells may be responsible for the airway hyper reactivity that is a feature of bronchial allergic asthma. There are mainly to type of inflammation which are as follows

ACUTE INFLAMMATION

It is characterized with increased vascular permeability, capillary infiltration and emigration of leukocyte.

CHRONIC INFLAMMATION

It is defined as prolonged process in which tissue destruction and inflammation occurs at the same time. It is characterized with infiltration of mononuclear immune cells, macrophages, monocytes, neutrophils, fibroblast activation, angiogenesis and fibrosis.It is associated with infiltration of mononuclear immune cells, macrophages, monocytes, neutrophils, fibroblast activation, proliferation (angiogenesis) and fibrosis.

Rheumatoid arthritis (RA), a chronic autoimmune disorder affecting about 1% of people in developed countries, manifests with typical signs such as local redness, swelling, pain, heat, and reduced function. Nitric oxide (NO), a short- lived free radical, plays a crucial role in inflammation modulation. It is synthesized from L-arginine by Nitric Oxide Synthase (NOS), with three isoforms identified. Constitutive NOS isoforms are calcium/calmodulin-dependent,
while inducible NOS (iNOS) is calcium/calmodulin-independent and regulated by inflammatory mediators. Increased NOS activity and NO release occur in both acute and chronic

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inflammation models. Administering L-arginine, a precursor for NO synthesis, exacerbates paw swelling in arthritis models

THE RELEVANCE OF PLANT EXTRACTS IN MODERN THERAPEUTICS

Plants especially Herbal plants differ from modern allopathic drugs, which typically consist of single active components targeting specific pathways. Instead, medicinal plants utilize a holistic approach where numerous molecules work synergistically on various elements of complex cellular pathways. For centuries, medicinal plants have provided a vast array of biologically active compounds, either in their crude form or as purified substances, for treating diverse diseases. The popularity of herbalmedicines has grown due to concerns about the toxicity and side effects associated with allopathic treatments. These plants play a crucial role in developing potent therapeutic agents. Globally, over 1.5 million practitioners of traditional medicine utilize medicinal plants for preventive, promotional, and curative purposes. India, boasting the world's largest repository of medicinal plants, occupies a significant position in the production of raw materials for crude drugs and as sources of bioactive compounds used in pharmaceuticals, cosmetics, and other applications

PHYTOCHEMICALS FOR ANTI INFLAMMATORY ACTIVITY

Class of Phytochemicals	Subclass	Example of Plant	Mechanism
Flavonoids	Flavones, Flavonols	Quercetin (found in onions, apples)	Inhibit inflammatory enzymes (e.g., cyclooxygenase, lipoxygenase), reduce oxidative stress
		Kaempferol (found in kale, broccoli)	Inhibit inflammatory enzymes, reduce oxidative stress
		Apigenin (found in chamomile)	Inhibit inflammatory enzymes, reduce oxidative stress
Terpenoids	Monoterpenes, Sesquiterpenes	Limonene (found in citrus fruits)	Modulate inflammatory pathways, reduce oxidative stress
		β-Caryophyllene (found in black pepper)	Modulate inflammatory pathways, reduce oxidative stress
Saponins	Triterpenoid Saponins, Steroidal Saponins	Ginseng (Panax ginseng)	Modulate immune response, reduce inflammation
		Licorice Root (Glycyrrhiza glabra)	Inhibit inflammatory pathways, enhance anti-inflammatory effects
Alkaloids	Isoquinoline, Tropane	Curcuma longa (Turmeric)	Inhibit inflammatory enzymes, modulate inflammatory signaling
		Berberine (found in Goldenseal)	Inhibit inflammatory enzymes, reduce oxidative stress
Glycosides	Cardiac Glycosides, Flavonoid	Elderberry (Sambucus nigra)	Modulate immune response, inhibit

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	Glycosides		inflammatory pathways
		Aloe Vera (Aloe barbadensis)	Reduce inflammatory cytokines, enhance wound healing
Phenolic Acids	Hydroxycinnamic Acids, Hydroxybenzoic Acids	Coffee (Coffea arabica)	Scavenge free radicals, inhibit inflammatory enzymes
		Oregano (Origanum vulgare)	Scavenge free radicals, inhibit inflammatory pathways
Phenolic Acids	Hydroxybenzoic, Hydroxycinnamic	Curcumin(from turmeric), **Resveratrol** (found in grapes, berries)	Suppress inflammationby inhibiting NF-κB, reducing cytokine production, and blocking inflammatory enzymes.
Terpenoids	Diterpenes, Triterpenes	Boswellicacids **(**from Boswellia serrata), Gingerols (from ginger)	Inhibit leukotriene synthesis and5-lipoxygenase , reduce inflammation in chronic conditions like arthritis.
alkaloids	Indole alkaloids	Berberine (foundin goldenseal)	Modulate inflammatory responses by inhibiting
		Capsaicin (from chili peppers)	NF-κB activation and reducing cytokine production. Inhibit substance P, a neuropeptide involved in inflammatory processes, and reduce pain and inflammation
Polyunsaturated Fatty Acids	Omega-3 fatty acids	Eicosapentaenoicacid (EPA)(from fish oil) Alpha- linolenicacid (ALA)(found in flaxseed)	Reduce production of inflammator y eicosanoids (prostagland ins, leukotrienes) And cytokines, modulate
			immune cell functions.
Saponins	Triterpenoid saponins	Ginsenosides (from Panaxginseng) Quillajasaponins (FromQuillaja	Modulate immune responses, inhibit NF-κB And MAPK Signaling

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		saponaria)	pathways Involved in inflammation
Carotenoids	Xanthophylls, Carotenes	Lutein (found in spinach, kale) Beta-carotene (found in carrots**)**	Possess antioxidant Properties that mitigate oxidative Stress Induced inflammation.

Plant Name	Family	Plant Part	Type of Extract	Biological Name
Turmeric	Zingiberaceae	Rhizome	Curcumin extract	Curcuma longa
Ginger	Zingiberaceae	Rhizome	Gingerol extract	Zingiber officinale
Willow Bark	Salicaceae	Bark	Salicin extract	Salix purpurea L
Boswellia	Burseraceae	Resin	Boswellic acid extract	Boswellia serrata
Green Tea	Theaceae	Leaves	Catechin extract	Camellia sinensis
Ashwagandha	Solanaceae	Root	Withanolide extract	Withania somnifera
Holy Basil	Lamiaceae	Leaves	Eugenol extract	Ocimum sanctum
Echinacea	Asteraceae	Roots/Leaves	Echinacoside extract	Echinacea purpurea
Hemp	Cannabaceae	Seeds/Leaves	Cannabinoids extract	Cannabis sativa
Peppermint	Lamiaceae	Leaves	Menthol extract	Mentha piperita L
Chili Pepper	Solanaceae	Fruit	Capsaicin extract	Capsicum annuum
Arnica	Asteraceae	Flower	Arnica extract	Arnica montana
Basil	Lamiaceae	Leaves	Essential oil extract	Ocimumbasilicum
Cayenne Pepper	Solanaceae	Fruit	Capsaicin extract	Capsicum frutescens
Rosemary	Lamiaceae	Leaves	Rosmarinic acid extract	Rosmarinus officinalis
Elderberry	Adoxaceae	Fruit	Elderberry extract	Sambucus nigra
Nettle	Urticaceae	Leaves	Nettle extract	Urtica dioica
Dandelion	Asteraceae	Root/Leaves	Taraxasterol extract	Taraxacum officinale
Licorice Root	Fabaceae	Root	Glycyrrhizin extract	Glycyrrhiza glabra
Cinnamon	Lauraceae	Bark	Cinnamaldehyde extract	Cinnamomum verum
Ginseng	Araliaceae	Root	Ginsenosides extract	Panax ginseng
Aloe Vera	Asphodelaceae	Leaves	Aloe vera gel/extract	Aloe barbadensis
Black Currant	Grossulariaceae	Seed/Leaves	Gamma-linolenic acid extract	Ribes nigrum
Coriander	Apiaceae	Seeds/Leaves	Essential oil extract	Coriandrum sativum
Cucumber	Cucurbitaceae	Fruit	Cucumber extract	Cucumis sativus
Olive Leaf	Oleaceae	Leaves	Oleuropein extract	Olea europaea

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Cardamom	Zingiberaceae	Seeds	Essential oil extract	Elettaria cardamomum
Hawthorn	Rosaceae	Berries/Leaves	Hawthorn extract	Crataegus monogyna
Sea Buckthorn	Elaeagnaceae	Berries/Leaves	Sea buckthorn extract	Hippophaerhamnoides
Marshmallow	Malvaceae	Root/Leaves	Mucilage extract	Althaea officinalis
Skullcap	Lamiaceae	Leaves/Roots	Flavonoid extract	Scutellarialateriflora
Ginger Mint	Lamiaceae	Leaves	Essential oil extract	Mentha × gracilis
Pineapple	Bromeliaceae	Fruit	Bromelain extract	Ananas comosus
Yellow Dock	Polygonaceae	Root	Extracts of anthraquinones	Rumex crispus
Gotu Kola	Apiaceae	Leaves/Stem	Triterpene extract	Centella asiatica
Sage	Lamiaceae	Leaves	Essential oil extract	Salvia officinalis
Fenugreek	Fabaceae	Seeds	Saponins extract	Trigonella foenum-graecum
Rhodiola	Crassulaceae	Root	Rosavins extract	Rhodiola rosea
Soursop	Annonaceae	Leaves/Fruit	Extracts of acetogenins	Annona muricata
Yarrow	Asteraceae	Leaves/Flowers	Essential oil extract	Achillea millefolium

In-Vitro Methods to Assess Anti- Inflammatory Activity

1.Inhibition of Protein Denaturation

Background: Protein denaturation is associated with loss of biological function and is linked to inflammatory disorders such as rheumatoid arthritis, diabetes, and cancer.Therefore, assessing a substance's ability to prevent protein denaturation can provide insights into its anti-inflammatory potential.

Assay Procedure:

In this experiment, various concentrations of plant extract (ranging from 100 to 500 µg/mL) are prepared in a total volume of 1000 µL, with the protein source being 200 µL of egg albumin or 450 µL of a 5% w/v aqueous bovine serum albumin (BSA) solution. The mixture is then combined with 1400 µL of phosphate-buffered saline (PBS) and incubated at 37°C for 15 minutes, followed by heating at 70°C for 5 minutes. After incubation and heating, the mixture is cooled under running tap water, and the absorbance is measured at660 nm. For controls, distilled water is used in place of the plant extract as the negative control, while acetylsalicylic acid, diclofenac sodium, ibuprofen, or indomethacin serve as positive controls. The percent inhibition of denaturation is calculated using the formula [(1 - D/C) × 100], where D represents the absorbance of the test sample and C represents the absorbance of the negative control.

2.Membrane Stabilization Method

Background: During inflammation, lysosomal membranes can lyse, leading to the release of enzymes that exacerbate inflammation. Stabilization of these membranes can be an effective anti-inflammatory strategy. Human or animal red blood cells (RBCs) are used as a model due to their membrane similarities to lysosomal membranes.

Assay Procedure:

To assess membrane stabilization, prepare a suspension of human, rat, or mouse erythrocytes. For hypotonic hemolysis, expose the erythrocytes to a hypotonic solution. For heat-induced hemolysis, incubate the erythrocytes at56°C for 30 minutes. After these treatments, measure the extent of hemolysis by assessing the absorbance at 540 nm. Compare the degree of hemolysis in the presence of the test substance with that in its absence to evaluate the effectiveness of the test substance in stabilizing the erythrocyte membrane.

3.Anti-Cyclooxygenase Activity

Background: Cyclooxygenase (COX) enzymes are involved in the production of prostaglandins, which mediate inflammation.

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Inhibitors of COX can thus serve as anti-inflammatory agents.

Assay Procedure:

For the assay, prepare the reaction mix with various concentrations of test compounds and include a reference drug such as aspirin or indomethacin, along with other chemicals as specified by the manufacturer's instructions. Shake the plate briefly and incubate it at 25°C for 5 minutes. Initiate the reaction by adding 20 µL of arachidonic acid and 20 µL of TMPD. Measure the absorbance at 590 nm using amicroplate reader. Use wells with no test compounds as controls to compare the results.

4.Anti-Lipoxygenase Activity

Background: Lipoxygenase enzymes contribute to inflammation through the metabolism of arachidonic acid. Inhibiting lipoxygenase can reduce inflammatory responses.

Assay Procedure:

To prepare the reaction mixture, combine 160 µL of 100 mM sodium phosphate buffer (pH 8.0) with various concentrations of test extract (10, 25, 50, 100, 200 µg/mL) and 20 µL of soybean lipoxygenase solution (167 U/mL).Initiate the reaction by adding 10 µL of sodium linoleic acid solution and measure the absorbance at 234 nm every minute for 3 minutes. Positive references for comparison include nordihydroguaiaretic acid (NDGA), indomethacin, or quercetin, while the control consists of the reaction mixture without the plant extract or drug. Calculate the **percentinhibition using the formula [(Abs control - Abs extract) / Abs control × 100].**

In-Vivo Methods

1.Carrageenan-Induced Paw Edema

Background: Carrageenan induces paw edema in rats in two phases: an early phase driven by histamines and kinins, and a later phase involving prostaglandins and proteases.

Assay Procedure:

Administer the test drugs either orally or intraperitoneally 30 minutes prior to the carrageenan injection. For the carrageenan challenge, inject 0.1 mL of a 1% carrageenan suspension into the subplantar region of the rat's hind paw. Measure the paw volumes both before and at 1-hour intervals for 6 hours following the injection. To assess the anti-inflammatory effect, calculate the percent inhibition of edema using the formula [(Ev0 - Evt) / Ev0 × 100], where Ev0represents the initial paw volume and Evt denotes the volume after treatment.

2.Histamine-Induced Paw Edema

Background: Histamine is involved in acute inflammatory responses and can induce paw edema in a similar manner to other inflammatory mediators.

Assay Procedure:

For the histamine challenge, inject 0.1 mL of a 1% histamine solution into the sub plantar region of the hind paw.Measure the paw volume before the injection and then at hourly intervals for 6 hours to monitor the response.

3.Arachidonic Acid-Induced Ear Oedema

Background: Arachidonic acid (AA) induces rapid ear edema in mice, which peaks at 1 hour. It is useful for evaluating both cyclooxygenase and lipoxygenase inhibitors.

Assay Procedure:

Apply 4 mg of arachidonic acid (AA) to the mouse ear. Assess the ear swelling at 1, 3, and 6 hours post-application to evaluate the inflammatory response.

4.Acetic Acid-Induced Vascular Permeability

Background: Acetic acid increases vascular permeability, leading to fluid leakage and inflammation. This model is used to assess the effect of test compounds on vascular permeability.

Assay Procedure:

Inject 0.2 mL of 0.25% Evans blue dye intravenously, followed by an intraperitoneal injection of 1 mL of 0.6% acetic acid one hour later. After 30 minutes, sacrifice the animals, wash the peritoneal cavity with normal saline, and measure the dye concentration in the supernatant at 610 nm to assess the inflammatory response.These methods provide a comprehensive framework for evaluating the anti-inflammatory activity of substances, incorporating both in-vitro and in-vivo assays. Each method includes a clear procedural outline and calculation formulas to assess the efficacy of test compounds.

II. CONCLUSION

In conclusion, the wide range of plant extracts explored in this review demonstrates their

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considerable potential in reducing inflammation. The findings reveal their effectiveness across different experimental models and suggest their potential as complementary treatments for inflammatory conditions. Future research is crucial to clarify the underlying mechanisms and refine the therapeutic uses of these natural compounds. Continued investigation into plant-based anti-inflammatory agents may lead to innovative and integrative approaches for managing chronic inflammation and improving overall health

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