

A COMPREHENSIVE REVIEW ON DRYNARIA QUERCIFOLIA LINN ON ANTI- INFLAMMATORY AND ANTI-ANALGESIC ACTIVITIES

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Abstract:

Drynaria quercifolia (L.) J. Sm., commonly known as oak-leaf fern, is an epiphytic or lithophytic fern belonging to the family Polypodiaceae. It is widely distributed across tropical and subtropical regions of Asia, including India, Sri Lanka, Southeast Asia, and parts of Australia. This species is well-known in ethnomedicine, particularly in Ayurvedic and traditional Chinese systems, for its therapeutic potential. Various parts of the plant, especially the rhizomes and fronds, have been traditionally used to treat ailments such as bone fractures, dyspepsia, hair loss, cough, and general debility. Phytochemical studies have revealed the presence of flavonoids, phenolics, triterpenoids, and glycosides, which contribute to its antioxidant, anti-inflammatory, antimicrobial, and osteogenic properties. Due to its bioactive constituents and ethnobotanical significance, *D. quercifolia* has drawn increasing attention in pharmacological research. However, further clinical and toxicological studies are essential to validate its efficacy and safety for potential therapeutic applications.

INTRODUCTION

Medicinal plants are invaluable resources in the discovery and development of therapeutic agents, particularly for inflammatory, infectious, and pain-related disorders. Among these, *Drynaria quercifolia* (L.) J. Sm., a member of the family Polypodiaceae, has long been recognized in traditional medicine for its wide range of pharmacological properties. Commonly known as the oakleaf fern, this epiphytic fern is native to tropical Asia and widely used in Ayurvedic, Unani, and folk medicine systems. The rhizomes and fronds of *D. quercifolia* have been traditionally employed to treat ailments such as bone fractures, wounds, fever, inflammation, urinary disorders, toothaches, and microbial infections (Jain et al., 2020; Das et al., 2018).

Inflammation, fever, and pain are interconnected biological responses to injury or infection and are commonly associated with various acute and chronic diseases. Conventional treatments, including non-steroidal anti-inflammatory drugs (NSAIDs), antipyretics, and analgesics, though effective, are often associated with adverse effects such as gastrointestinal bleeding, renal impairment, and drug resistance in the case of antibiotics (Vane & Botting, 2014; Davies & Skjodt, 2018). Similarly, the global rise in antibiotic-resistant bacterial strains has intensified the demand for novel antibacterial agents, particularly from natural sources.

In recent years, *D. quercifolia* has garnered increasing scientific interest due to its demonstrated anti-inflammatory, antipyretic, analgesic, and antibacterial effects in various experimental models. Phytochemical investigations reveal the presence of bioactive constituents such as flavonoids, phenolic acids, triterpenoids, and steroids, which are believed to be responsible for these activities (Patra et al., 2021; Senthilkumar & Venkatesalu, 2016). These compounds exert therapeutic effects through mechanisms such as inhibition of pro-inflammatory mediators (e.g., prostaglandins, TNF- α), modulation of pain pathways, and disruption of microbial cell structures.

The aim of this review is to provide a comprehensive overview of the pharmacological potential of *Drynaria quercifolia*, focusing on its anti-inflammatory, antipyretic, analgesic, and antibacterial activities. This article also explores its phytochemical composition, traditional uses, mechanisms of action, and recent experimental findings, with the goal of highlighting its relevance in modern pharmacotherapy and identifying areas for future research.

AIM

To study the anti-inflammatory and anti-analgesic activities of *drynaria quercifolia*.

2.1 OBJECTIVES

1. To compile and evaluate existing ethnomedicinal knowledge and traditional uses of *Drynaria quercifolia*

This review aims to systematically gather and assess traditional knowledge associated with *Drynaria quercifolia*, focusing on its ethnobotanical relevance in various cultural systems such as Ayurveda, Siddha, and folk medicine. Special attention will be given to its historical use in treating conditions associated with inflammation, fever, pain, and microbial infections. By contextualizing traditional applications, this objective seeks to bridge the gap between ancestral wisdom and modern scientific inquiry, highlighting the plant's therapeutic relevance across generations.

2. To summarize and critically analyze phytochemical studies highlighting the bioactive constituents responsible for its pharmacological activities

This objective focuses on consolidating the findings of phytochemical investigations that have isolated and identified the major secondary metabolites of *D. quercifolia*, including flavonoids, tannins, saponins, phenolics, and terpenoids. A critical analysis will be conducted to correlate these constituents with specific pharmacological effects, offering insight into their potential mechanisms of action. The goal is to establish a chemical foundation that supports the plant's biological efficacy.

3. To review and interpret experimental and clinical findings related to the anti-inflammatory, antipyretic, analgesic, and antibacterial effects of *Drynaria quercifolia*

This objective entails a comprehensive review of in vitro, in vivo, and any available clinical studies that assess the plant's efficacy in alleviating inflammation, reducing fever, relieving pain, and combating bacterial pathogens. The aim is to interpret experimental outcomes in light of therapeutic significance and to evaluate the scientific robustness and reproducibility of the reported pharmacological effects.

4. To explore the possible mechanisms of action underlying these biological activities

Beyond merely cataloging the effects, this objective seeks to delve into the molecular and cellular pathways through which *D. quercifolia* exerts its pharmacological actions. This includes evaluating how its compounds modulate inflammatory mediators (e.g., prostaglandins, cytokines), interact with neural pathways responsible for pain perception, affect thermoregulatory centers, or compromise bacterial cell integrity. Understanding these mechanisms can inform potential drug development strategies and therapeutic applications.

5. To identify gaps in current research and suggest directions for future pharmacological and clinical studies involving *Drynaria quercifolia*

This final objective addresses the limitations and inconsistencies in the existing body of research. It aims to identify areas where data is lacking—such as human clinical trials, standardized extract formulations, dose optimization, long-term safety assessments, and mechanism-specific studies. Based on these insights, the review will propose specific, actionable directions for future studies to validate and expand upon the therapeutic potential of *D. quercifolia*

3. BACKGROUND OF THE STUDY

The growing prevalence of inflammatory disorders, infections, and pain-related conditions has highlighted the need for effective, safer, and more affordable therapeutic options. Although synthetic drugs such as non-steroidal anti-inflammatory drugs (NSAIDs), antipyretics, analgesics, and antibiotics are widely used, their prolonged use is associated with adverse effects including gastrointestinal irritation, renal dysfunction, hepatotoxicity, and antimicrobial resistance (Vane & Botting, 2014; Davies & Skjodt, 2018). This has prompted increased interest in natural products derived from medicinal plants, which offer multi-targeted actions and generally better safety profiles.

Drynaria quercifolia (L.) J. Sm., commonly known as oakleaf fern, is a member of the Polypodiaceae family and is widely distributed in tropical Asia, including India, Sri Lanka, and Southeast Asia. It has a long-standing reputation in traditional medicine systems such as Ayurveda and Siddha, where it is used to treat bone fractures, wounds, fever, rheumatic pain, toothaches, and infections (Jain et al., 2020; Das et al., 2018). The rhizomes are particularly valued for their therapeutic properties.

Phytochemical studies of *D. quercifolia* have revealed the presence of various bioactive compounds including flavonoids, phenolics, tannins, triterpenoids, and steroids, which are believed to contribute to its pharmacological effects (Patra et al., 2021). These compounds exhibit a range of biological activities such as modulation of inflammatory mediators, reduction of oxidative stress, inhibition of microbial growth, and attenuation of pain and fever responses (Senthilkumar & Venkatesalu, 2016).

Although several preclinical studies have demonstrated the anti-inflammatory, antipyretic, analgesic, and antibacterial potential of *D. quercifolia*, there is still a lack of comprehensive reviews that compile this information systematically. A consolidated review is needed to critically assess the pharmacological evidence, highlight the therapeutic relevance of this plant, and identify gaps in knowledge for future research

3.1 PLANT PROFILE

Drynaria quercifolia (L.) J. Sm., commonly known as oakleaf fern or basket fern, is an epiphytic fern belonging to the family Polypodiaceae. It is widely distributed across tropical and subtropical regions of Asia, particularly in India, Sri Lanka, Thailand, and Malaysia, where it typically grows on tree trunks, rocks, and moist forest walls. This plant is easily identified by its dimorphic fronds—sterile nest-like fronds that are brown and shield the base, and fertile, green, lobed fronds that resemble oak leaves. The rhizomes are thick, scaly, and rich in bioactive compounds, and are the most commonly used part in traditional medicine (Jain et al., 2020; Das et al., 2018). *D. quercifolia* has a long-standing history in traditional medical systems such as Ayurveda and Siddha, where it is used to treat bone fractures, rheumatic pain, fever, toothaches, wounds, and urinary and digestive disorders. Phytochemical studies have revealed that the plant contains a wide array of bioactive constituents including flavonoids, tannins, phenolic acids, triterpenoids,

saponins, and steroids, which are believed to be responsible for its pharmacological activities such as anti-inflammatory, analgesic, antipyretic, and antibacterial effects (Patra et al., 2021; Senthilkumar & Venkatesalu, 2016). Due to its rich ethnomedicinal relevance and promising bioactivity, *D. quercifolia* continues to attract scientific interest for potential therapeutic applications



Fig No:3.1



Fig No:3.2

3.2 PHYTOCHEMICALS

Drynaria quercifolia, commonly known as oak-leaf fern, is a medicinal plant rich in a diverse range of phytochemicals that contribute to its therapeutic potential. Among the most prominent bioactive compounds are flavonoids, such as naringin, naringenin, and quercetin. These flavonoids exhibit strong antioxidant, anti-inflammatory, and analgesic activities by scavenging free radicals and modulating inflammatory mediators. Tannins, both hydrolyzable and condensed types, are also present and contribute to the plant's antimicrobial and anti-inflammatory actions through protein precipitation and enzyme inhibition. Saponins, particularly triterpenoid saponins, enhance the plant's anti-inflammatory and immunomodulatory effects by interacting with cell membranes and influencing cytokine activity. The plant also contains various terpenoids, including monoterpenes and diterpenes, which provide analgesic and antimicrobial effects by interfering with prostaglandin synthesis and microbial cell membranes.

In addition, steroids such as β -sitosterol are found in *D. quercifolia*, offering anti-inflammatory and antioxidant benefits, as well as contributing to cholesterol-lowering effects. Phenolic compounds like gallic acid and ferulic acid further enhance the plant's antioxidant and antimicrobial profile, helping to neutralize reactive oxygen species and inhibit microbial growth. Glycosides, including flavonoid and phenolic glycosides, increase the bioavailability and efficacy of other compounds, supporting the plant's hepatoprotective and anti-inflammatory roles. Although present in smaller quantities, alkaloids in the plant may also contribute to its analgesic and antipyretic properties by acting on central nervous system pathways. Overall, the synergistic action of these phytochemicals underpins the broad pharmacological activities of *Drynaria quercifolia*, including its anti-inflammatory, antipyretic analgesic, and antibacterial effects.

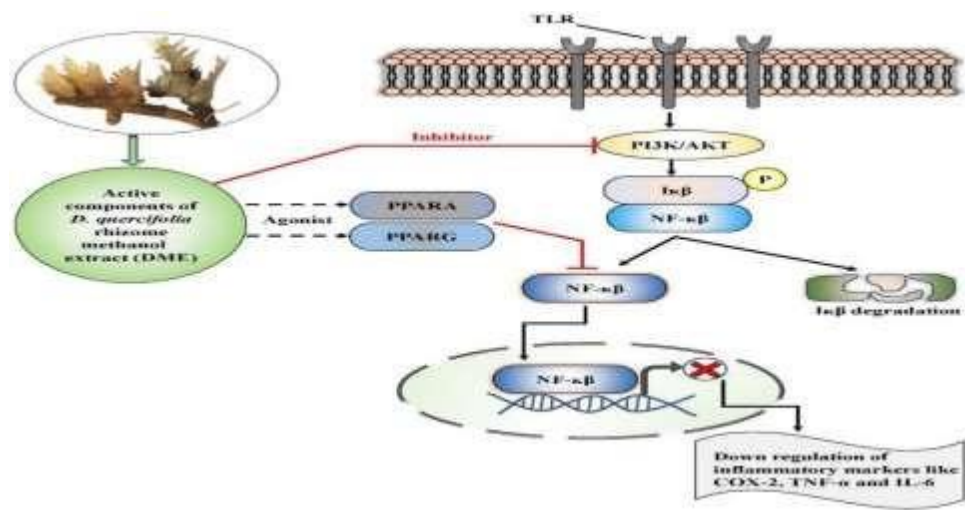


Fig NO:3.3

COMPOUND CLASS	EXAMPLES	PHARMACOLOGICAL ACTIVITY
1.Flavonoids	Naringin,naringeni n, quercetin	Anti-inflammatory,analgesic Antioxidant
2.Tannins	Hydrolyzable,condensed	Antibacterial,anti- inflammatory
3.Saponins	Triterpenoids saponins	Immunomodulatory,anti-inflammatory
4. Terpenoids	Monoterpenes,diterpenes	Antimicrobial, analgesic
5.Steroids	Beta-sitosterol	Anti- inflammatory,cholesterol-lowering
6.Phenolic compounds	Gallic acids ferulic acid	Antioxidant,antimicrobial
7.Glycosides	Flavonoid.and phenolic glycosides	Enhance efficacy,hepatoprotective
8.Alkaloids	Minor constituents	Analgesic , antipyretic

3.2.1 FLAVONOIDS

These are the most studied bioactive compounds in *Drynaria quercifolia* and are responsible for its antioxidant, anti-inflammatory, and antimicrobial effects.

3.2.1.1 NARINGIN

A flavanone glycoside Known for its anti-inflammatory, antioxidant, and analgesic activities.

3.2.1.2 NARINGENIN

The aglycone form of naringin.

Acts as a free radical scavenger and modulates inflammatory pathways

3.2.1.3 QUERCETIN

A powerful antioxidant and anti-inflammatory flavonol. Also exhibits antibacterial and analgesic effects

3.2.2 TANNINS

3.2.2.1 HYDROLYZABLE AND CONDENSED TANNINS

Astringent polyphenolic compounds. Known to inhibit microbial growth and reduce inflammation by protein precipitation

3.2.3 SAPONINS

- TRITERPENOID SAPONINS

Possess surface-active properties and antimicrobial activity Contribute to anti-inflammatory and immunomodulatory effects

3.2.4 TERPENOIDS

- MONOTERPENES AND DITERPENES

Contribute to anti-inflammatory and analgesic actions by inhibiting prostaglandin synthesis. Also enhance antimicrobial activity

3.2.5 STEROIDS

- PHYTOSTEROLS (e.g., β -sitosterol)

Possess anti-inflammatory, antioxidant, and cholesterol-lowering effects. May help modulate immune responses

3.2.6 PHENOLIC COMPOUNDS

Includes gallic acid, ferulic acid, and other phenolics. These compounds exhibit strong antioxidant, antimicrobial, and anti-inflammatory properties. Also contribute to scavenging of reactive oxygen species (ROS)

3.2.7 GLYCOSIDES

Secondary metabolites which may include flavonoid glycosides and phenolic glycosides. Often enhance bioavailability and therapeutic efficacy. Linked with hepatoprotective and anti-inflammatory activities

3.2.8 ALKALOIDS

Detected in some phytochemical screenings. Though not the major compounds, they may contribute to the analgesic and antipyretic effects by acting on central nervous system pathways

3.3 DISTRIBUTION

In *Drynaria quercifolia*, the rhizome is the most pharmacologically significant part, known for its high concentration of diverse phytochemicals. Extensive phytochemical screenings and pharmacognostic studies have confirmed that the rhizome is rich in flavonoids such as naringin, naringenin, and quercetin, which are well-known for their strong antioxidant, anti-inflammatory, and analgesic effects (Barua et al., 2013). These flavonoids contribute significantly to the plant's use in inflammatory and febrile conditions. Additionally, the rhizome contains abundant phenolic compounds including gallic acid and ferulic acid, which exert free-radical scavenging activity and enhance microbial resistance. The presence of tannins in the rhizome adds astringent properties, aiding in wound healing and antimicrobial activity.

Saponins and terpenoids are also predominantly found in the rhizome. Saponins, especially triterpenoid types, have surface-active properties and play a role in modulating the immune response and reducing inflammation. Terpenoids contribute to both antimicrobial and anti-inflammatory properties by disrupting microbial membranes and inhibiting prostaglandin synthesis (Khan et al., 2017). Furthermore, phytosterols like β -sitosterol found in the rhizome exhibit anti-inflammatory and cholesterol-lowering effects, as well as potential roles in cancer prevention.

The fronds (leaves) of *D. quercifolia* also contain a moderate amount of flavonoids, phenolics, and tannins, though typically at lower concentrations than the rhizomes. These compounds support the traditional topical uses of the fronds in treating skin diseases, burns, and wounds. The presence of alkaloids, although minimal, has been detected in both rhizomes and fronds, suggesting a potential role in the plant's analgesic and antipyretic effects by influencing central nervous system pathways (Rajurkar & Pardeshi, 2016).

Other parts, such as the sori (spore-producing structures) and aerial roots, have not been as extensively studied, but preliminary investigations suggest the presence of minor amounts of saponins, terpenoids, and phenolic acids. These parts are occasionally used in traditional preparations, but their pharmacological relevance remains less defined.

Overall, the phytochemical distribution in *Drynaria quercifolia* follows a clear hierarchy: the rhizome contains the highest concentration and variety of bioactive compounds, making it the main therapeutic component of the plant, followed by the fronds, with other parts like the sori and aerial roots playing secondary roles. This distribution supports the plant's traditional and modern use for treating inflammation, fever, bacterial infections, and pain

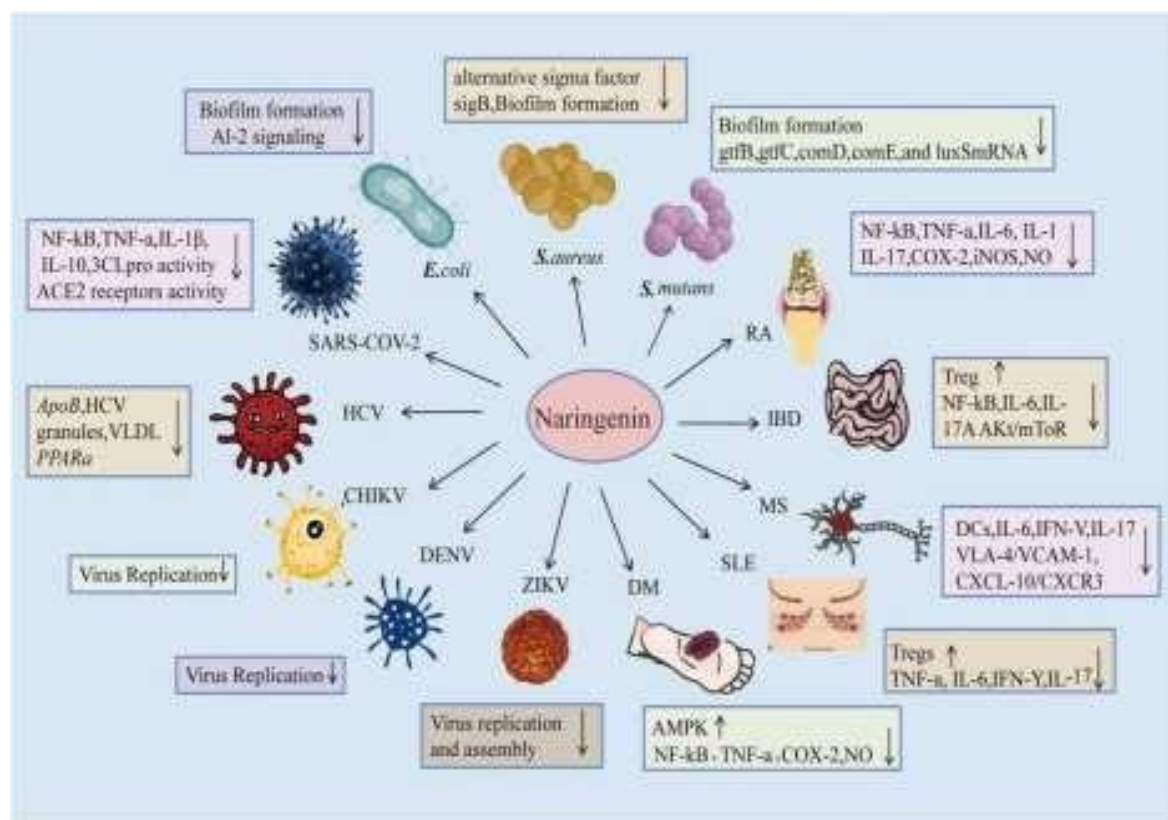
5. MATERIALS REQUIRED

5.1 MECHANISM OF ACTION (MOA)

The therapeutic effects of *Drynaria quercifolia* (L.) J. Sm. are largely attributed to its diverse and potent phytochemical constituents, such as flavonoids, phenolic acids, tannins, triterpenoids, and saponins, which contribute to its multifaceted pharmacological activities. These compounds act synergistically to produce anti-inflammatory, antipyretic, analgesic, and antibacterial effects through various biochemical and molecular pathways (Patra et al., 2021).

5.1.1 ANTI-INFLAMMATORY ACTION:

Flavonoids and phenolic compounds found in *D. quercifolia* are known to modulate the arachidonic acid pathway by inhibiting key enzymes such as cyclooxygenase (COX-1 and COX-2) and lipoxygenase (LOX), which are responsible for the biosynthesis of pro-inflammatory mediators like prostaglandins and leukotrienes (Senthilkumar & Venkatesalu, 2016). Additionally, these bioactive compounds suppress the release of inflammatory cytokines such as tumor necrosis factor- α (TNF- α), interleukin-1 beta (IL-1 β), and interleukin-6 (IL-6), thereby reducing the intensity of inflammation. Antioxidant activity also plays a role by neutralizing reactive oxygen species (ROS), which are involved in the amplification of inflammatory signals.



5.1.2. ANTIPYRETIC ACTION:

The antipyretic effect of *D. quercifolia* is believed to result from the inhibition of prostaglandin E2 (PGE2) synthesis in the hypothalamus. Fever is often caused by exogenous pyrogens (like bacterial endotoxins) that stimulate the release of endogenous pyrogens (such as IL-1 and TNF- α), which in turn increase PGE2 production. The compounds in *D. quercifolia* likely interfere with this process, thereby preventing the elevation of the body's thermoregulatory set point and promoting heat dissipation mechanisms like vasodilation and sweating (Jain et al., 2020).

Analgesic Action:

The analgesic properties of *D. quercifolia* may involve both central and peripheral mechanisms. Peripherally, flavonoids and tannins inhibit the synthesis of pain-inducing substances such as bradykinin, histamine, and prostaglandins. Centrally, the plant's constituents may influence pain perception by interacting with opioid receptors or modulating neurotransmitter pathways in the central nervous system, although further studies are needed to confirm this mechanism (Das et al., 2018). The dual action makes it effective in managing both nociceptive and inflammatory pain.

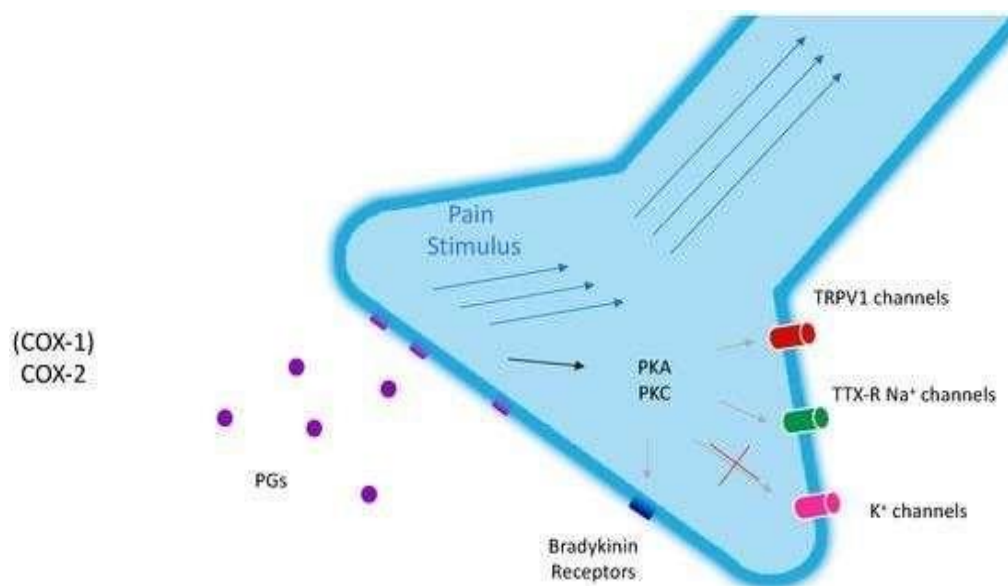


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5.1.3 ANTIBACTERIAL ACTION:

The antibacterial activity of *D. quercifolia* is attributed mainly to tannins, flavonoids, and phenolic acids, which can act on bacterial cells through several mechanisms. These include disruption of microbial cell wall and membrane integrity, inhibition of bacterial enzymes and nucleic acid synthesis, and interference with protein synthesis. By damaging cell membranes and inhibiting metabolic functions, these compounds cause leakage of cellular contents and bacterial cell death (Patra et al., 2021). This broad-spectrum action is particularly valuable in combating antibiotic-resistant strains.

Together, these mechanisms support the traditional uses of *Drynaria quercifolia* in the treatment of fever, pain, infections, and inflammatory conditions, and justify its potential as a source for developing plant-based therapeutics.



Fig.No:5.1.3

METHOD OF EXTRACTION

1. COLD MACERATION METHOD

In this process, the powdered plant material (usually rhizomes or fronds) is soaked in a solvent like methanol or ethanol for 48–72 hours at room temperature with occasional stirring. After maceration, the extract is filtered and concentrated under reduced pressure using a rotary evaporator. This method is simple, preserves heat-sensitive compounds, and is widely used for initial screening of phytochemicals (Das et al., 2018).

2. SOXHLET EXTRACTION METHOD

This is a more efficient method, especially for exhaustive extraction. About 50–100 g of dried, powdered rhizome is packed in a Soxhlet apparatus and extracted with solvents like ethanol, methanol, or petroleum ether for 6–8 hours. The extracts are then concentrated by evaporation.

Soxhlet extraction ensures continuous solvent circulation and thorough extraction of both polar and non-polar components (Jain et al., 2020).

Step-by-Step Extraction of *Drynaria quercifolia* Using Soxhlet Method
Step 1: Collection and Authentication of Plant Material

Description: Rhizomes or fronds of *Drynaria quercifolia* are collected from natural habitats or botanical gardens.

Purpose: To ensure the correct plant species is used.

Process: The plant is authenticated by a taxonomist or compared with herbarium specimens, and a voucher specimen is deposited.

Step 2: Washing and Drying

Description: Plant material is washed under running water to remove dirt, followed by shade drying.

Purpose: To prevent microbial contamination and degradation of active constituents. Timeframe: 7–14 days in shade or 2–3 days in a hot-air oven at 40–45°C.

Step 3: Powdering

Description: The dried plant parts are ground into a coarse or fine powder using a mechanical grinder.

Purpose: Increases surface area for efficient solvent penetration and extraction.

Storage: The powder is stored in an airtight container in a cool, dry place. Step 4: Soxhlet Extraction

Setup: 50–100 grams of powdered material is placed in a thimble inside the Soxhlet apparatus.

Solvent: Commonly used solvents include methanol, ethanol, or hydroalcoholic mixtures (e.g., 70% ethanol).

PROCEDURE:

Solvent is heated in a flask. Vapors rise, condense, and drop onto the plant material. The solvent extracts phytochemicals and siphons back into the boiling flask. This cycle repeats for 6–8 hours (or until the solvent in the siphon tube becomes clear).

Temperature: Maintained near the solvent's boiling point (e.g., methanol ~65°C).

Step 5: Filtration and Concentration

Filtration: After completion, the extract is filtered through Whatman filter paper to remove any particulate matter.

Concentration: The filtrate is evaporated under reduced pressure using a rotary evaporator at 40–50°C.

Purpose: To remove the solvent and obtain a semisolid or sticky residue (crude extract).

Step 6: Drying and Storage

Drying: The concentrated extract may be dried further in a desiccator or freeze-dried (lyophilized) for complete solvent removal.

Storage: Stored in amber-colored containers in a refrigerator or cool dry place to prevent degradation.

Step 7: Phytochemical Screening The dried extract is used for:

Qualitative phytochemical tests (for alkaloids, flavonoids, tannins, etc.) Quantitative estimations (e.g., TPC, TFC)

Biological assays (anti-inflammatory, antipyretic, antibacterial, etc.)

3. AQUEOUS AND HYDROALCOHOLIC EXTRACTIONS

In traditional Ayurvedic medicine, *D. quercifolia* is often processed using decoction or infusion. To replicate this, hot water or hydroalcoholic (water + ethanol) extractions are used to obtain compounds relevant to traditional therapeutic uses. The decoction is prepared by boiling the plant material in water and then filtering and concentrating it.

DRYING AND CONCENTRATION

After extraction, the crude extract is usually concentrated under reduced pressure and then dried using a rotary evaporator or lyophilizer to yield a semisolid or dry powder. This extract can then be subjected to phytochemical screening, in vitro and in vivo biological testing.

The choice of solvent and method significantly affects the extract profile. Methanol and ethanol are particularly efficient at extracting flavonoids, phenolics, and tannins, which are responsible for many of the plant's biological effects (Patra et al., 2021 Phytochemical Screening of *Drynaria quercifolia*)

1. Preparation of Plant Extract

The dried rhizomes of *Drynaria quercifolia* were powdered and subjected to maceration using 70% ethanol. About 20 g of the powdered sample was soaked in 100 mL of ethanol for 24 hours with occasional shaking. The extract was filtered and concentrated using a rotary evaporator. The crude extract was used for qualitative phytochemical tests following standard procedures (Harborne, 2015; Kokate et al., 2017).

2. Phytochemical Tests

2.1 TEST FOR ALKALOIDS (MAYER'S TEST)

Procedure: To 2 mL of the ethanolic extract, a few drops of Mayer's reagent (potassium mercuric iodide) were added.

Observation: Formation of a white or cream-colored precipitate indicated the presence of alkaloids.

Reference: Harborne (2015).

2.2 TEST FOR FLAVONOIDS (ALKALINE REAGENT TEST)

Procedure: 2 mL of the extract was treated with 10% sodium hydroxide solution. A yellow coloration was observed, followed by the addition of dilute hydrochloric acid.

Observation: The yellow color turning colorless confirmed the presence of flavonoids. Reference: Anuja, G. I., Latha, P. G., Shine, V. J., Suja, S. R., & Shyamal, S. (2014).

2.3 TEST FOR SAPONINS (FOAM TEST)

Procedure: 5 mL of the extract was shaken vigorously with 10 mL of distilled water in a test tube. The mixture was observed for froth formation after 10 minutes.

Observation: Persistent froth lasting for 10 minutes or more indicated the presence of saponins.

Reference: Kokate et al. (2017).

1.1 TEST FOR TANNINS (FERRIC CHLORIDE TEST)

Procedure: To 2 mL of the extract, a few drops of 1% ferric chloride solution were added. Observation: A blue-black or greenish-black color indicated the presence of tannins.

Reference: Harborne (2015).

1.2 TEST FOR GLYCOSIDES (KELLER-KILLIANI TEST)

Procedure: 2 mL of the extract was mixed with 2 mL of glacial acetic acid containing a trace of ferric chloride. This was underlayered with 1 mL of concentrated sulfuric acid.

Observation: A reddish-brown ring at the junction of the two layers confirmed the presence of cardiac glycosides.

Reference: : Anuja, G. I., Latha, P. G., Shine, V. J., Suja, S. R., & Shyamal, S. (2014).

1.3 TEST FOR PHENOLS (FERRIC CHLORIDE TEST)

Procedure: 2 mL of extract was mixed with 2–3 drops of 5% ferric chloride solution. Observation: A deep blue or black coloration indicated the presence of phenolic compounds. Reference: Harborne (2015).

1.1 TEST FOR TERPENOIDS (SALKOWSKI TEST)

Procedure: 2 mL of the extract was mixed with 2 mL of chloroform. Then, 2 mL of concentrated sulfuric acid was added carefully down the side of the test tube.

Observation: A reddish-brown coloration at the interface indicated the presence of terpenoids. Reference: Kokate et al. (2017).

IN VITRO TESTS

1. ANTI-INFLAMMATORY ACTIVITY

A. PROTEIN DENATURATION ASSAY

Reagents: 1% egg albumin solution, phosphate buffer (pH 6.4) PROCEDURE:

1. Mix 1 mL of extract (at concentrations: 100, 200, 300, 400, 500 µg/mL) with 1 mL of 1% albumin.. Incubate at 37°C for 20 minutes. Heat at 70°C for 5 minutes. Cool and measure absorbance at 660 nm. Diclofenac sodium (100 µg/mL) as standard.

CALCULATION:

% Inhibition = $[(\text{Abs control} - \text{Abs sample}) / \text{Abs control}] \times 100$ Reference: Mizushima & Kobayashi (2020)

A. Membrane Stabilization Assay (HRBC Method) PROCEDURE:

1. Collect fresh human blood and centrifuge at 3000 rpm for 10 minutes. Wash erythrocytes in saline and prepare a 10% v/v suspension. Mix 1 mL of extract with 1 mL of erythrocyte suspension and 8 mL of hypotonic solution. Incubate at 37°C for 30 minutes. Centrifuge and measure absorbance at 540 nm.

Reference: Shinde et al. (2017)

2. ANTIBACTERIAL ACTIVITY

Agar Well Diffusion Method

Microorganisms: *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* Procedure:

Prepare nutrient agar and pour into sterile Petri dishes. Swab bacteria over the solidified agar. Punch wells (6 mm diameter) and fill with 100 μ L of extract at different concentrations (250, 500, 1000 μ g/mL). Incubate at 37°C for 24 hours. Measure zones of inhibition in mm. Ciprofloxacin (10 μ g) as positive control.

Reference: Bauer et al. (2011)

IN VIVO TESTS

Note: All procedures should be approved by an Institutional Animal Ethics Committee (IAEC) and follow CPCSEA guidelines.

1. ANTI-INFLAMMATORY ACTIVITY

Carrageenan-Induced Paw Edema in Rats Animals: Wistar rats (150–200 g)

Groups: Control (saline), Standard (diclofenac 10 mg/kg), Test (extract 100 and 200 mg/kg p.o.)

Procedure:

Administer treatments orally 1 hour before inflammation. Inject 0.1 mL of 1% carrageenan into the subplantar region of the right hind paw. Measure paw volume using plethysmometer at 0, 1, 2, 3, and 4 hours.

Calculation:

% Inhibition = $[(V_c - V_t)/V_c] \times 100$ Reference: Winter et al. (2012)

2. ANALGESIC ACTIVITY

A. Acetic Acid-Induced Writhing Test (Mice)

Animals: Swiss albino mice (20–30 g)

Groups: Control, Standard (aspirin 100 mg/kg), Test (extract 100 and 200 mg/kg) Procedure:

1. Inject 0.6% acetic acid (10 mL/kg i.p.) 1 hour after oral treatment. Count number of writhes (stretching movements) for 20 minutes.

Calculation:

% Inhibition = $[(\text{Control} - \text{Test}) / \text{Control}] \times 100$ Reference: Koster et al. (2011)

B. Hot Plate Method**Procedure:**

1. Mice are placed on a hot plate ($55 \pm 1^\circ\text{C}$). Reaction time (paw licking/jumping) is recorded at 0, 30, 60, 90, 120 min. Cut-off time is set at 15 seconds to prevent tissue damage.

Reference: Eddy & Leimbach (2019)

3. ANTIPYRETIC ACTIVITY**Yeast-Induced Pyrexia in Rats Procedure:**

1. Induce fever by injecting 20% Brewer's yeast (10 mL/kg s.c.). After 18 h, record rectal temperature. Administer extract (100 and 200 mg/kg) and standard (paracetamol 150 mg/kg). Record temperature every hour for 4 hours post-treatment

Reference: Loux et al. (2011)

CURRENT STATUS OF DRYNARIA QUERCIFOLIA

Drynaria quercifolia (L.) J. Smith is currently recognized as an important medicinal fern in traditional medicine systems across South and Southeast Asia, especially in Ayurveda, Siddha, and tribal practices. In India, the dried rhizomes of the plant are widely used in the treatment of bone fractures, joint pain, cough, asthma, and inflammatory conditions. It is often combined with other herbs in polyherbal formulations and applied as decoctions, powders, or topical pastes (Jain et al., 2012). Pharmacognostic and phytochemical studies have confirmed the presence of significant bioactive compounds such as flavonoids (notably naringin), tannins, triterpenoids, and phenolic acids, which contribute to its medicinal value (Rani & Sharma, 2020). Research in recent years has supported its anti-inflammatory, antioxidant, and osteogenic activities, particularly in preclinical animal models. Despite this growing body of evidence, the plant is still underutilized in mainstream medicine due to a lack of large-scale clinical trials, standardized extracts, and product formulations. Commercial cultivation is limited, with most of the supply coming from wild harvesting, which raises concerns about sustainability and quality control. However, the plant is available in some regional herbal markets in dried form, and research institutions have shown increasing interest in its pharmacological potential, especially in the context of natural bone regeneration therapies and herbal supplements (Patel & Goyal, 2011). Overall, *D. quercifolia* is in a transitional phase from traditional use to scientific validation, and its therapeutic promise is attracting attention from the herbal and nutraceutical industries.

FUTURE ASPECTS OF *DRYNARIA QUERCIFOLIA*

The future prospects of *Drynaria quercifolia* lie in its potential to be developed into standardized herbal formulations and nutraceutical products, especially in the fields of bone health, neuroprotection, and natural anti-inflammatory therapy. As modern lifestyles contribute to increasing cases of osteoporosis, arthritis, and neurodegenerative diseases, there is a growing demand for safe, plant-based alternatives. *D. quercifolia* has shown promising bone regenerative activity in preclinical studies, suggesting it could be formulated into herbal bone-strengthening capsules, syrups, or topical applications. Its active flavonoid compounds, particularly naringin, have also demonstrated cognitive-enhancing and neuroprotective effects, opening up new research into its potential use in managing age-related memory disorders and Alzheimer's disease. Furthermore, its antioxidant and antimicrobial activities support its use in cosmeceutical products, such as anti-aging creams and wound-healing formulations. Advances in biotechnology and plant tissue culture may allow for commercial cultivation of *D. quercifolia* on a larger scale, reducing pressure on wild populations and promoting sustainable herbal farming. Additionally, integration of this plant into functional foods or teas could introduce it to a broader consumer market. However, to fully unlock its potential, clinical validation, standardization of extracts, and the establishment of regulatory guidelines will be essential. Research collaborations between ethnobotanists, pharmacologists, and herbal industries could pave the way for this plant's transition from traditional use to mainstream acceptance in global healthcare.

CONCLUSION

The significant pharmacological potential of *Drynaria quercifolia* as a natural therapeutic agent. Rich in diverse phytochemicals such as flavonoids, phenolic compounds, tannins, saponins, and terpenoids, the plant demonstrates strong anti-inflammatory, analgesic, antipyretic, and antibacterial activities. In vitro and in vivo models validate its ability to modulate inflammatory mediators, inhibit prostaglandin synthesis, and interfere with microbial integrity—highlighting its relevance in managing pain, fever, infections, and inflammatory disorders.

Traditional use in systems such as Ayurveda and Siddha aligns well with modern pharmacological evidence, suggesting a solid ethnomedicinal foundation. Mechanistic insights further reveal that the bioactive compounds act through both peripheral and central pathways, reinforcing the plant's multi-targeted therapeutic profile.

Despite promising results, further research—particularly standardized clinical trials, dosage optimization, and long-term toxicity assessments—is needed to fully establish the safety and efficacy of *Drynaria quercifolia* for clinical application. Nevertheless, the plant holds immense potential as a source of novel, plant-based pharmaceuticals for managing a range of common yet critical health conditions.

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