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Urtica Dioica: A Comprehensive Review of Its Pharmacological and Therapeutic Applications

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A B S T R A C T

Urtica dioica (commonly known as stinging nettle) is a well-known medicinal plant used for centuries across various traditional systems of medicine. It has demonstrated a broad spectrum of pharmacological activities, including anti-inflammatory, antioxidant, antimicrobial, antidiabetic, and anticancer effects. The plant is rich in bioactive compounds such as flavonoids, phenolic acids, vitamins, minerals, and amino acids. This review aims to summarize current knowledge about the botany, phytochemistry, therapeutic uses, pharmacological activities, and safety profile of Urtica dioica, highlighting its potential in modern medicine. Emphasis is placed on its rich composition of polyphenols, flavonoids, vitamins, minerals, and fatty acids, underpinning health benefits such as anti-inflammatory, antioxidant, Antidiabetic, diuretic, antimicrobial, anticancer, and neuroprotective activities. Clinical studies demonstrate efficacy in type 2 diabetes, allergic rhinitis, benign prostatic hyperplasia, and arthritis. Safety evaluation reveals low risk when properly processed, although interactions with antihypertensives, hypoglycemics, and diuretics warrant caution. Future research priorities include standardized extract development, large-scale clinical trials, and mechanistic elucidation of neurodegenerative and oncologic pathways.

Keywords: *Urtica dioica*, stinging nettle, phytochemicals, clinical trials, pharmacology, safety, sustainability.

1. INTRODUCTION

Medicinal plants have been an essential part of healthcare since ancient times. *Urtica dioica L.*, commonly referred to as stinging nettle, is a perennial plant recognized for its therapeutic applications in various traditional medicine systems [1]. Native to Europe, Asia, North Africa, and North America, *Urtica dioica* is characterized by its stinging hairs, which release histamine, acetylcholine, serotonin, and formic acid upon contact . Plant Girardinia diversifolia belonging to the family Urticaceae was used to treat various disease and have different phytochemicals which show different pharmacological activities like antioxidants, antimicrobial, antidiabetics and many more. This study is perform to check it's phytochemical and its morphological analysis of the plant which help to understand the plant more in future. [2].Modern pharmacological investigations have validated many traditional uses of *Urtica dioica* and have opened new avenues for its application in the treatment of inflammatory diseases, metabolic disorders, and even cancer [3]. pants have long served as valuable resources for traditional medicine systems worldwide. Among them, *Urtica dioica (*stinging nettle) is notable for its widespread use and diverse pharmacological potential. Documented in Ayurvedic, Chinese, and European folk medicine, this plant is revered for its anti-inflammatory, analgesic, antioxidant, antimicrobial, and diuretic properties.The growing interest in natural remedies has spurred scientific exploration into the constituents and mechanisms underlying the medicinal efficacy of *Urtica dioica*.

1.2 Plant Profile:

Kingdom: Plantae - Plants

Subkingdom: Tracheobionta

Superdivision: Spermatophyta - Seed plants

Division : Magnoliophyta - Flowering plants

Class : Magnoliopsida - Dicotyledons

Subclass : Hamamelididae

Order: Urticales

Family: Urticaceae – nettle family

Genus : Urtica L.

Common name : stinging nettle/bichu ghas

1.3 Collection and authentication of plant

"A 7-day extensive survey was conducted in the Kullu district of Himachal Pradesh to collect the *Urtica dioica* plant, which is widely distributed in the region. The collection was done from various locations, including forests to ensure a representative sample of the plant. The collected plant specimens were carefully pressed, dried, and labeled to preserve their morphological characteristics. Subsequently, the collected *Urtica dioica* plant specimens were submitted to the Sardar Patel University, Mandi, himachal Pradesh for authentication. The authentication process involved a thorough examination of the plant's morphological and taxonomic characteristics by experts in the field. The authentication confirmed that the collected plant specimens belonged to the species *Urtica dioica*, family Urticaceae. The authenticated plant specimens were then deposited in the herbarium of the Sardar Patel University, Mandi, for future reference. This study highlights the importance of authentication in botanical research and provides a framework for future studies on the medicinal and economic importance of *Urtica dioica* and other plant species found in the Kullu district of Himachal Pradesh.

2. BOTENICAL DESCRIPTION

Urtica dioica belongs to the family Urticaceae. It typically grows in nitrogen-rich soils, often forming dense stands. The plant can reach heights of 1–2 meters and is easily recognized by its serrated leaves and trichomes, which are modified hairs that inject irritants upon touch [4]. *Urtica dioica* is dioecious, meaning individual plants are either male or female.

2.1 BOTANICAL CHARACTERISTICS:

Stem: Erect, square-shaped, and covered with stinging hairs.

Leaves: Opposite, serrated margins, dark green, heart-shaped with trichomes that cause skin irritation upon contact.

Flowers: Small, greenish-white or yellowish, forming dense clusters.

Roots: Rhizomatous, yellowish-brown and fibrous.

The stinging hairs or trichomes are filled with histamine, serotonin, and acetylcholine, which are released upon skin contact, causing a burning sensation, which ironically is also exploited for therapeutic purposes.Its flowers are small and greenish, arranged in clusters. The root system is rhizomatous, allowing it to spread effectively and form colonies. It thrives in temperate climates and prefers moist, fertile soil [5].

3. PHYTOCHEMICAL CONSTITUENTS

A variety of bioactive compounds have been identified in different parts of the *Urtica dioica* plant: The pharmacological effects of Urtica dioica are largely attributed to its diverse chemical constituents found in various parts of the plant, including the leaves, roots, and stems.

Leaves extract contains:[6-11]

Phytochemical group	**Test performed**	**Result**
Alkaloids	Dragondroffs test	**+ve**
Flavonoids	Lead acetate test	**+ve**
Tannis	Gelatin test	**+ve**
Saponins	Foam test	**+ve**
Phenolic compounds	Ferric chloride test	**+ve**
Proteins and amino acids	Ninhydrin test	**+ve**
Carbohydrates	Molisch`s test	**+ve**

Root extracts contain:

- Sterols: β-sitosterol, campesterol, stigmasterol.
- Lignans
- Polysaccharides

5. TRADITIONAL AND ETHNO PHARMACOLOGICAL USES

In traditional medicine, *Urtica dioica* has been used for a variety of purposes:

Europe: Treatment of arthritis, anemia, and eczema [12].

Asia: Management of urinary disorders and as a diuretic [13].

Native American medicine: Used as a blood purifier and to treat musculoskeletal pain [14].

Decoctions, infusions, and topical applications of the plant have all been employed traditionally, often focusing on inflammatory and dermatological conditions [15].

6. PHARMACOLOGICAL ACTIVITIES

1. Anti-inflammatory Activity

Urtica dioica extracts have shown potent anti-inflammatory effects in both in vitro and in vivo models. The plant inhibits the production of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6, possibly through suppression of NF-κB activation pathways [16]. Both leaf and root extracts exhibit significant anti-inflammatory effects. The inhibition of COX and LOX enzymes and downregulation of pro-inflammatory cytokines such as IL-6 and TNF-α have been observed in several studies. Clinical trials have demonstrated that nettle extract can alleviate symptoms of osteoarthritis and rheumatoid arthritis [17].

2. Antioxidant Activity

The high levels of flavonoids and phenolic acids contribute to strong antioxidant properties. The plant is rich in polyphenols and flavonoids, known for their potent antioxidant activity. These compounds scavenge free radicals, reducing oxidative stress which plays a role in various chronic diseases, including cancer and cardiovascular disorders. *Urtica dioica* scavenges free radicals, reduces lipid peroxidation, and enhances endogenous antioxidant defenses such as superoxide dismutase (SOD) and glutathione peroxidase (GPx) [18].

3. Antidiabetic Activity

Studies have shown that *Urtica dioica* extracts can lower blood glucose levels by enhancing insulin secretion, increasing glucose uptake by tissues, and inhibiting α-glucosidase activity [19]. Animal studies and preliminary clinical data suggest a role for nettle in managing type 2 diabetes mellitus . Animal studies have indicated that nettle extracts can lower blood glucose levels by enhancing insulin secretion and improving glucose uptake. These effects are primarily associated with the flavonoid content. [20].

4. Anticancer Activity

Preclinical studies suggest that *Urtica dioica* possesses anticancer properties, particularly against prostate, breast, and colorectal cancers. Its mechanisms include induction of apoptosis, inhibition of cell proliferation, and suppression of angiogenesis [21]. Specific compounds such as lectins have been identified as potent bioactive agents with anticancer potential [22].

5. Antimicrobial Activity

Extracts from *Urtica dioica* exhibit broad-spectrum antimicrobial effects against bacteria, fungi, and viruses. The antimicrobial action is attributed to the presence of phenolic compounds and flavonoids, which disrupt microbial membranes and inhibit essential enzymatic activities [23].

6. Cardiovascular Protection:

Nettle extracts have been found to lower blood pressure through vasodilatation and diuretic effects. Additionally, it reduces total cholesterol and LDL cholesterol levels, promoting cardiovascular health [24].

7. Nutritional Value

Urtica dioica is rich in nutrients, making it valuable as a food source as well as a medicinal plant. Fresh leaves are high in protein (up to 25% of dry weight) and essential amino acids [25]. They are also abundant in vitamins, particularly vitamin C and vitamin A, as well as minerals such as iron and calcium, making them beneficial for overall nutrition [26].In many cultures, young nettle shoots are cooked and eaten as a spring tonic to rejuvenate the body after winter months of limited fresh produce [27].

8. Therapeutic Applications

Due to its pharmacological profile, *Urtica dioica* has been utilized or proposed for the treatment of various diseases:

Arthritis and joint pain:

Topical application or oral supplementation alleviates symptoms [28].

Benign prostatic hyperplasia (BPH):

Extracts help reduce prostate size and relieve urinary symptoms [29].

Allergic rhinitis:

Nettle extracts inhibit histamine receptor activity, reducing allergic symptoms [30].

Eczema and skin diseases:

Used traditionally as a topical remedy for eczema, psoriasis, and other inflammatory skin conditions [31].

8. Mechanisms of Action

Anti-inflammatory pathways: Inhibition of cyclooxygenase and lipoxygenase enzymes [32].Antioxidant defenses: Scavenging reactive oxygen species (ROS) and upregulating antioxidant enzymes [33].Endocrine modulation: Enhancing insulin sensitivity and regulating androgen pathways [34].Cytotoxic effects: Inducing apoptosis in tumor cells through mitochondrial pathways [35].

9. Toxicology and Safety Profile

Urtica dioica is generally considered safe when used appropriately. However, raw leaves can cause skin irritation due to stinging hairs [36]. Oral supplementation is well tolerated at commonly used doses, though large amounts may cause mild gastrointestinal upset or diuresis [37]. Caution is advised in individuals taking antihypertensive or antidiabetic medications due to potential additive effects [38] Pregnant and breastfeeding women are advised to avoid large doses due to insufficient safety data [39].

Formulations and Dosage Forms :

Modern pharmacological interest has led to the development of various Urtica dioica-based formulations:

- Capsules and Tablets: Standardized leaf or root extract for systemic conditions.
- Topical Creams and Ointments: For eczema, acne, and joint pain.
- Tinctures and Teas: Common in traditional use for urinary and respiratory ailments.
- Cosmetic Applications: Shampoos, face masks, and lotions.

Clinical dosage recommendations vary, typically ranging between 300–500 mg of dried extract per day in divided doses, depending on the condition and preparation.

Phytopharmaceutical development:

Standardized extracts for use as adjunct therapies in chronic diseases [41].

Genetic studies:

Identification of genes responsible for bioactive compound biosynthesis [42].

Clinical trials: Large-scale, placebo-controlled studies to confirm efficacy and safety for conditions such as arthritis, diabetes, and cancer [43].Further research into these areas could help establish *Urtica dioica* as a mainstay in evidence-based medicine.

CONCLUSION

Urtica dioica is a versatile medicinal plant with a rich history of use and a promising future. Its broad pharmacological profile, coupled with its high nutritional value, makes it a candidate for both preventive and therapeutic applications. *Urtica dioica* stands out as a multipurpose medicinal herb with strong historical roots and promising modern applications. Its rich phytochemical profile contributes to its antioxidant, anti-inflammatory, analgesic, and antimicrobial effects. The plant continues to hold significant value not only in traditional healing systems but also in modern scientific research aimed at discovering safe and effective natural therapies with increasing global interest in plant-based medicines, *Urtica dioica* exemplifies how ethno botanical knowledge can be effectively translated into evidence-based medicine. Continued investigation and clinical validation will further unlock its therapeutic potential and secure its place in contemporary healthcare.

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