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## A Comprehensive Review on the Phytochemistry, Medicinal Properties, and Traditional Uses of *Euphorbia hirta* L.

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### ABSTRACT

*Euphorbia hirta* L., widely known as asthma weed, is a tropical and subtropical herbaceous plant extensively used in traditional medicinal systems around the world. This review consolidates a broad spectrum of existing literature on its phytochemical makeup, therapeutic properties, and ethnopharmacological relevance. The plant is rich in diverse secondary metabolites including flavonoids, tannins, terpenoids, alkaloids, and phenolic acids, which are primarily responsible for its wide-ranging biological activities such as antioxidant, anti-inflammatory, antimicrobial, antidiarrheal, and antiasthmatic effects. Traditionally, *E. hirta* has been employed in the treatment of ailments like asthma, bronchitis, gastrointestinal disorders, skin infections, and even as supportive therapy in dengue fever. Scientific investigations have validated several of these traditional claims, highlighting its potential for modern therapeutic applications. However, there remain gaps in standardized clinical studies and toxicological assessments, which are crucial for ensuring safe and effective use. This review not only emphasizes the pharmacological promise of *Euphorbia hirta* but also advocates for continued multidisciplinary research to harness its full medicinal potential in the



## Introduction

*Euphorbia hirta* L., commonly referred to as asthma weed, belongs to the Euphorbiaceae family and is a well-known herbaceous plant widely distributed across tropical and subtropical regions of the world. It is an annual hairy plant that grows commonly in open grasslands, along roadsides, and in disturbed areas such as fields and pathways. The species thrives in warm, moist environments and is often regarded as a weed due to its prolific growth. Despite this perception, *E. hirta* holds a significant place in traditional medicine and is revered for its diverse pharmacological properties.

Historically, the plant has played a critical role in indigenous and folk medicine systems across Asia, Africa, and Latin America. In India, it is widely used in Ayurvedic preparations for treating respiratory disorders like asthma and bronchitis, which has led to its common name. Similarly, traditional Chinese medicine (TCM) has utilized the plant for its anti-inflammatory and antidiarrheal properties. In African countries, it is known for its effectiveness in treating skin infections, gastrointestinal disturbances, and fever. The Philippines has popularized its use as a supportive treatment for dengue fever, where it is commonly prepared as a decoction known locally as “Tawa-tawa.”

The growing interest in herbal medicine and natural products research has led to an increasing focus on *E. hirta* in the scientific community. Researchers are particularly interested in its rich composition of phytochemicals and their potential health benefits. Numerous studies have been conducted to explore and validate its medicinal claims, and findings suggest that the plant contains a variety of bioactive compounds including flavonoids, tannins, saponins, alkaloids, and essential oils. These constituents are believed to contribute to the plant’s pharmacological activities such as antimicrobial, antioxidant, anti-inflammatory, and antidiarrheal effects.

The phytochemical richness of *E. hirta* supports its diverse bioactivities. Flavonoids like quercetin and rutin are potent antioxidants, helping to neutralize free radicals and protect cells from oxidative damage. Tannins are known for their astringent and antimicrobial properties, while terpenoids and saponins have demonstrated anti-inflammatory and immunomodulatory effects. Additionally, the essential oils extracted from the plant have shown antimicrobial and antifungal activities, suggesting potential applications in natural product-based antimicrobial formulations.



From a pharmacological perspective, *E. hirta* demonstrates significant promise as a plant-based therapeutic. Its anti-inflammatory and analgesic effects are supported by several *in vivo* studies using animal models, wherein plant extracts reduced inflammation and pain in induced models of edema and nociception. The antimicrobial activity has been tested against a range of bacterial and fungal pathogens, affirming its potential role in treating infections. Antidiarrheal properties have also been verified through experimental studies that show decreased intestinal motility and fluid secretion.

In addition to its bioactive profile, *E. hirta* is of considerable interest due to its availability and affordability. In many low-resource settings where access to modern medicine is limited, traditional remedies continue to be an important component of primary healthcare. The widespread availability of *E. hirta* makes it a valuable resource for communities that rely on herbal medicine for the treatment of common ailments. Its therapeutic efficacy, when properly understood and harnessed, could offer cost-effective alternatives to synthetic drugs, especially in managing chronic and infectious diseases.

Despite its longstanding traditional use and emerging pharmacological validation, there are still gaps in our understanding of *Euphorbia hirta*. Most studies have focused on crude extracts, and there is a need for research that isolates and characterizes individual bioactive compounds to determine their exact mechanisms of action. Moreover, while *in vitro* and animal studies have provided valuable insights, clinical trials in human populations are essential to establish efficacy, dosage, and safety profiles.

Toxicological studies have shown that while *E. hirta* is generally safe at traditional doses, high concentrations or prolonged use may lead to adverse effects, including hepatotoxicity and cytotoxicity. This underscores the need for standardized preparations and regulated usage. Regulatory bodies and researchers must work together to create quality standards for herbal preparations, ensuring that plant-derived therapies are safe and effective.

Furthermore, as the popularity of herbal medicine increases, there is a risk of overharvesting and ecological imbalance. Sustainable harvesting practices and conservation efforts must be implemented to protect natural populations of *Euphorbia hirta*, particularly in areas where it forms a part of traditional healthcare systems. Cultivation techniques and agronomic studies could also support the large-scale production of the plant for medicinal use.

In summary, *Euphorbia hirta* is a versatile medicinal plant with a rich ethnobotanical history and a promising future in modern phytotherapy. Its widespread traditional use, diverse chemical composition,



and broad pharmacological activities make it a candidate for further research and development. By bridging traditional knowledge with modern scientific approaches, researchers and practitioners can unlock the full therapeutic potential of this humble herb. The integration of *E. hirta* into evidence-based healthcare practices will require collaborative efforts in phytochemistry, pharmacology, toxicology, and clinical research.

### Phytochemical Constituents

*Euphorbia hirta* is a phytochemically rich plant, characterized by a wide spectrum of secondary metabolites that contribute significantly to its pharmacological and therapeutic potential. The primary classes of bioactive compounds identified in various parts of the plant include flavonoids, tannins, alkaloids, terpenoids, phenolic compounds, saponins, and essential oils. Modern phytochemical investigations using chromatographic and spectroscopic techniques have facilitated the identification and characterization of several key constituents.

**Flavonoids** are among the most abundant and pharmacologically significant phytochemicals in *E. hirta*. The principal flavonoids include quercetin (3,3',4',5,7-pentahydroxyflavone), kaempferol (3,4',5,7-tetrahydroxyflavone), rutin (quercetin-3-O-rutinoside), and myricetin (3,3',4',5,5',7-hexahydroxyflavone). These compounds are known for their antioxidant, anti-inflammatory, and antimicrobial properties. Quercetin and kaempferol in particular have been shown to scavenge reactive oxygen species (ROS) and inhibit inflammatory mediators such as prostaglandins and cytokines.

**Tannins**, particularly hydrolyzable tannins such as gallic acid and ellagic acid, and condensed tannins like catechins, are responsible for the astringent, antimicrobial, and wound-healing activities of *E. hirta*. These compounds precipitate proteins and form protective layers over wounds, thereby preventing microbial invasion and promoting healing.

**Alkaloids** such as euphorbin-A, euphorbin-B, and phyllanthin have been isolated from the aerial parts of the plant. Alkaloids typically exhibit strong physiological activity, and those found in *E. hirta* have demonstrated antispasmodic, antidiarrheal, and bronchodilatory properties, aligning with traditional uses in asthma and gastrointestinal disorders.

**Terpenoids** present in *E. hirta* include  $\beta$ -amyrin,  $\alpha$ -amyrin, lupeol, and friedelin. These triterpenes have been associated with anti-inflammatory and hepatoprotective activities. Lupeol, in particular, has shown strong antioxidant and anticancer properties in various studies. Additionally, diterpenoids specific to the



Euphorbia genus, such as ingenol derivatives, may contribute to its cytotoxic and anti-proliferative effects.

**Phenolic acids**, including gallic acid, caffeic acid, and ferulic acid, contribute to the plant's strong antioxidant potential. These compounds donate hydrogen atoms to neutralize free radicals and reduce oxidative stress, a common pathway in many chronic diseases. Their presence also enhances the plant's anti-inflammatory and antimicrobial profile.

**Saponins**, another important class of compounds in *E. hirta*, possess surfactant properties and are known for their immune-modulatory, anti-inflammatory, and cholesterol-lowering effects. They form stable froths in aqueous solutions and can disrupt microbial membranes, which explains their antibacterial and antifungal actions.

**Essential oils** from *E. hirta* are complex mixtures of monoterpenes and sesquiterpenes. Notable components identified include limonene, pinene, caryophyllene, and camphor. These oils exhibit broad-spectrum antimicrobial and insecticidal activities. The aromatic nature of these oils also contributes to the traditional inhalation-based remedies for respiratory conditions.

**Steroids** such as stigmasterol and  $\beta$ -sitosterol are also present and are implicated in the plant's anti-inflammatory and lipid-lowering effects. These plant sterols structurally resemble cholesterol and help modulate lipid metabolism and inflammatory responses in the human body.

#### Chemical Structures of Key Phytochemicals:

1. **Quercetin** – A flavonol with five hydroxyl groups and a typical flavone backbone ( $C_{15}H_{10}O_7$ ).
2. **Kaempferol** – Similar to quercetin but with one less hydroxyl group ( $C_{15}H_{10}O_6$ ).
3. **Lupeol** – A pentacyclic triterpene with the molecular formula  $C_{30}H_{50}O$ .
4.  **$\beta$ -sitosterol** – A phytosterol structurally similar to cholesterol ( $C_{29}H_{50}O$ ).
5. **Gallic acid** – A simple phenolic acid with three hydroxyl groups on a benzoic acid backbone ( $C_7H_6O_5$ ).

These compounds can be identified and quantified using analytical techniques such as high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), nuclear magnetic



resonance (NMR), and ultraviolet-visible spectroscopy (UV-Vis). Each method has advantages in detecting and isolating specific types of metabolites based on their polarity, molecular weight, or light absorption properties.

Overall, the diverse array of phytochemicals in *E. hirta* not only supports its traditional uses but also suggests new avenues for drug discovery. By isolating and characterizing these compounds, researchers can better understand their mechanisms of action and develop targeted phytotherapeutic agents. This rich chemical profile underscores the importance of *Euphorbia hirta* as a reservoir of bioactive molecules with significant pharmacological potential.

### Medicinal Properties

*Euphorbia hirta* exhibits a broad spectrum of medicinal properties attributed to its rich phytochemical profile. The various bioactive constituents contribute to its antioxidant, anti-inflammatory, antimicrobial, antidiarrheal, antiasthmatic, analgesic, antidiabetic, antifungal, wound healing, and anticancer activities. These pharmacological effects have been validated through several in vitro, in vivo, and limited clinical investigations.

**Antioxidant Activity:** The presence of flavonoids (such as quercetin and rutin), phenolic acids (gallic acid, caffeic acid), and triterpenoids (lupeol) in *E. hirta* underlies its potent antioxidant activity. These compounds neutralize free radicals and prevent oxidative stress-induced damage to cellular components, thereby protecting against degenerative diseases like cancer, cardiovascular disorders, and neurodegenerative conditions. Antioxidant assays such as DPPH, ABTS, and FRAP have demonstrated high radical scavenging activity in extracts of *E. hirta*, particularly in ethanol and methanol-based preparations.

**Anti-inflammatory Properties:** The anti-inflammatory potential of *E. hirta* is linked to its capacity to inhibit pro-inflammatory mediators such as prostaglandins, nitric oxide (NO), and cytokines like TNF- $\alpha$  and IL-6. Flavonoids and terpenoids modulate signaling pathways like NF- $\kappa$ B and MAPK, which play key roles in the inflammation process. Topical and oral preparations of *E. hirta* have been shown to reduce inflammation in models of carrageenan-induced paw edema and other inflammatory assays.

**Antimicrobial and Antifungal Activities:** Extracts from *E. hirta* have demonstrated inhibitory effects against a range of Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. The antimicrobial action is primarily due to the presence



of tannins, saponins, flavonoids, and essential oils. These compounds disrupt microbial membranes, inhibit enzyme function, and interfere with microbial replication. Antifungal activity has also been observed against *Candida albicans* and *Aspergillus* species, indicating the plant's potential in treating skin infections and fungal diseases.

**Antidiarrheal and Antispasmodic Effects:** Traditional use of *E. hirta* for treating diarrhea has been supported by pharmacological studies. The plant exhibits antidiarrheal effects through modulation of intestinal motility, reduction of gastrointestinal secretions, and inhibition of prostaglandin synthesis. These effects are attributed to the presence of alkaloids, tannins, and flavonoids. In experimental models, *E. hirta* extracts significantly reduced the frequency and intensity of diarrhea induced by castor oil and other agents.

**Antiasthmatic and Bronchodilatory Effects:** The traditional use of *E. hirta* in treating asthma and respiratory ailments is validated by its bronchodilatory and anti-inflammatory properties. The alkaloids and flavonoids relax bronchial smooth muscles and reduce airway resistance. Additionally, the plant inhibits histamine release and stabilizes mast cells, further reducing bronchospasm and airway inflammation.

**Analgesic and Antipyretic Effects:** The analgesic effects of *E. hirta* are linked to its action on the central and peripheral pain pathways. Animal models have shown that the plant extracts reduce pain perception in hot plate and writhing tests. These effects are synergistically enhanced by its anti-inflammatory action. Similarly, antipyretic activity is evidenced by a reduction in fever in models induced with yeast, possibly through inhibition of prostaglandin E<sub>2</sub> synthesis in the hypothalamus.

**Antidiabetic Potential:** Studies have demonstrated the ability of *E. hirta* extracts to lower blood glucose levels in streptozotocin-induced diabetic rats. The antihyperglycemic activity is linked to improved insulin sensitivity and glucose uptake, as well as the presence of flavonoids and saponins that modulate carbohydrate metabolism. Though promising, further clinical studies are needed to substantiate these findings.

**Wound Healing and Dermatological Applications:** The astringent and antimicrobial properties of *E. hirta* make it effective in wound healing. Topical application of the plant extract promotes wound contraction, epithelialization, and collagen deposition. It is also used traditionally for treating skin



eruptions, boils, and fungal infections. The healing effects are primarily due to the combined action of tannins, flavonoids, and phenolic compounds.

**Anticancer and Cytotoxic Effects:** Preliminary studies suggest that certain compounds in *E. hirta*, including flavonoids and terpenoids, exhibit cytotoxic effects on cancer cell lines such as HeLa and MCF-7. The mechanisms may involve apoptosis induction, DNA damage, and disruption of cellular proliferation pathways. However, the therapeutic potential requires validation through detailed mechanistic and clinical studies.

**Other Activities:** *E. hirta* also exhibits immunomodulatory, antiulcer, hepatoprotective, and antimalarial properties. These effects are under active investigation, and while some studies are promising, comprehensive pharmacodynamic and toxicological evaluations are necessary to establish clinical relevance.

Overall, the medicinal properties of *Euphorbia hirta* substantiate its extensive use in ethnomedicine and demonstrate its potential as a source for developing novel therapeutic agents. Future studies should focus on standardizing extracts, elucidating mechanisms of action, and conducting controlled clinical trials to fully harness its pharmacological capabilities.

### **Traditional and Ethnomedicinal Uses**

The traditional uses of *Euphorbia hirta* are diverse and reflect the plant's availability and significance in local healthcare systems. Across Asia, Africa, and Latin America, the herb has been an indispensable part of folk remedies, often administered as infusions, decoctions, or topical applications.

In India, Ayurvedic medicine utilizes *E. hirta* primarily for respiratory conditions. Decoctions of the whole plant or leaves are consumed to treat asthma, bronchitis, and cough. It is also used for gastrointestinal disturbances like diarrhea, dysentery, and intestinal parasites. The fresh latex is applied topically to treat warts, boils, and fungal infections. Women use it to stimulate milk production and regulate menstrual cycles.

In the Philippines, the plant is widely known as "Tawa-tawa" and is famously used as a supportive therapy for dengue fever. Folk practices suggest that decoctions help restore platelet counts and prevent internal bleeding, although scientific validation of this claim remains limited. Nevertheless, its popularity during dengue outbreaks has led to public health interest in its clinical evaluation.



In African traditional medicine, *E. hirta* is used to treat a variety of ailments including malaria, fevers, wounds, and snake bites. It is often employed in combination with other herbs, which may enhance its therapeutic potential or reduce toxicity. Decoctions are consumed orally or used in steam inhalation for respiratory benefits.

Latin American traditions also highlight the plant's utility in treating venereal diseases, skin infections, and urinary tract disorders. It is sometimes used as an abortifacient or contraceptive, reflecting a deep, albeit controversial, knowledge of its bioactive effects.

These diverse applications underscore the need for integrated research combining ethnobotanical knowledge with pharmacological and toxicological studies. Documentation of traditional usage patterns can provide valuable insights into effective therapeutic windows and potential contraindications.

### **Toxicological Considerations**

Despite its traditional acceptance, the safety profile of *Euphorbia hirta* warrants careful examination. Several studies have explored its acute and chronic toxicity, with mixed outcomes depending on dosage, extract type, and mode of administration.

The latex of the plant contains irritant compounds that may cause allergic reactions or skin inflammation upon contact. Oral toxicity studies in rats have shown that aqueous and ethanolic extracts are relatively safe at lower doses (up to 2000 mg/kg body weight), with no significant behavioral or histopathological changes. However, higher doses have been associated with hepatotoxicity, renal impairment, and cytotoxic effects on certain cell lines.

Cytotoxic and mutagenic activities of some extracts raise concerns about long-term use, particularly when consumed in large quantities or without proper processing. The variability in chemical composition based on environmental factors and extraction techniques further complicates safety assessments.

Therefore, while the traditional use of *E. hirta* suggests a favorable therapeutic index, modern applications must be guided by rigorous toxicological evaluations. Standardization of extract preparations, coupled with preclinical and clinical trials, is essential to ensure both efficacy and safety. Caution is especially warranted in vulnerable populations such as pregnant women, children, and individuals with liver or kidney conditions.

## Conclusion

*Euphorbia hirta* is a promising medicinal plant with a rich history of traditional use and a growing body of scientific validation. Its phytochemical constituents, particularly flavonoids and tannins, contribute to a wide range of pharmacological activities. Traditional applications across different cultures align well with findings from in vitro and in vivo studies, particularly in the treatment of respiratory and gastrointestinal disorders.

However, despite these promising attributes, further research is needed to isolate and characterize its active constituents, validate its clinical efficacy, and assess its safety profile through controlled studies. The integration of ethnomedicinal knowledge with modern pharmacology and toxicology holds the key to harnessing the full potential of *Euphorbia hirta* as a phytotherapeutic agent.

The future direction should include clinical trials, development of standardized herbal formulations, and exploration of potential interactions with conventional drugs. With growing global interest in plant-based remedies, *Euphorbia hirta* may emerge as a valuable resource in both primary healthcare and pharmaceutical innovation.

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