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REVIEW PAPER

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# Ethnobotanical use, phytochemical profile and pharmacological properties of *Euphorbia hirta* L.: A systematic review

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**Key words:** *Euphorbia hirta*, Ethnobotanical use, Phytochemical profile, Pharmacological properties, Systematic review

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**Abstract**

Medicinal plants are referred to as the 'gift of nature' due to their rich bioactive compounds that serve as alternative treatments for various diseases. The global reliance on herbal medicine has steadily increased, particularly in developing countries, with an estimated 60% of the global population depending on herbal remedies for healthcare. The World Health Organization reports that 80% of people in developing regions rely on plant-based treatments. Among these plants, *Euphorbia hirta* (*E. hirta*) is widely recognized for its broad therapeutic potential, having been used in traditional medicine for respiratory conditions, skin disorders, digestive issues, urinary tract infections. The plant contains various bioactive compounds, such as flavonoids, alkaloids, tannins, saponins, and terpenoids, contributing to its anti-inflammatory, antimicrobial, antioxidant, anti-diabetic, and anti-asthmatic properties. Recent research has elucidated the molecular mechanisms behind these effects, including modulation of oxidative stress, inhibition of inflammatory cytokines, and interaction with key cellular pathways like NF-kB and MAPK. Despite its therapeutic promise, concerns over its potential toxicity, particularly in high doses, warrant caution. Adverse effects, such as skin irritation and gastrointestinal discomfort, have been reported, emphasizing the need for further research to determine safe dosage levels and to validate its clinical efficacy. This review highlights the multifaceted pharmacological benefits of *E. hirta*, while underscoring the importance of continued investigation into its safety and therapeutic applications, particularly for integration into modern medical practices.

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**INTRODUCTION**

Medicinal plants are the 'gift of nature' as they contain important bioactive chemical compounds used as an alternative approach to treating various diseases, and their use is steadily increasing across the globe (Miranda, 2021; De *et al.*, 2023). The World Health Organization (WHO) states that 60% of the global population relies on herbal medicine, with nearly 80% of people in developing countries depending almost entirely on it for their primary healthcare needs (Khan and Ahmad, 2019). Herbal medicine is estimated that around 28 000 to 35 000 herb species including various plant parts such as seeds, berries, roots, leaves, fruits, bark, flowers, or even entire plants are utilized for medicinal purposes worldwide (Pan *et al.*, 2014). The widespread use of herbal medicine, as highlighted by the WHO, underscores the importance of plants like *E. hirta*, which has been utilized for centuries across various cultures for its therapeutic properties. As one of the many medicinal plants, *E. hirta* exemplifies the diverse range of species that contribute to global healthcare, particularly in developing regions where traditional plant-based remedies are essential for primary healthcare.

*Euphorbia hirta*, commonly known as asthma weed, garden spurge, or hairy spurge, is a highly versatile medicinal plant with a rich history of traditional use across various cultures. This small annual herb is native to the tropical and subtropical regions of the Americas and was first scientifically classified in the 18$^{th}$ century by Swedish botanist Carl Linnaeus (Nick, 2022). It belongs to the Kingdom Plantae and is classified under the Division Spermatophyta, Class Dicotyledonae, and Order Euphorbiales. It is part of the Family Euphorbiaceae, the Genus *Euphorbia*, and the species *hirta* (Khursheed and Jain, 2022). While it is particularly valued for its effectiveness in treating respiratory ailments such as asthma, it is also recognized for its broad therapeutic potential in managing various conditions, including skin disorders, digestive issues, and infections. Beyond these, *E. hirta* has been shown to play a role in managing chronic diseases such as diabetes, hypertension, and even certain types of cancer, demonstrating its wide-ranging pharmacological benefits. As part of the Euphorbiaceae family and the *Euphorbia* genus, *E. hirta* is closely related to other medicinal species, including *Euphorbia helioscopia*, *Euphorbia antiquorum*, and *Euphorbia prostrata*. These plants share medicinal properties, with reports indicating their use in treating ailments like asthma, cancer, and malaria. Additionally, they are known for their anti-inflammatory, antioxidant, and antibacterial effects, making them highly valuable in both traditional and alternative medicine (Khursheed and Jain, 2022). Typically, this herb reaches a height of up to 50 cm and features erect or ascending stems covered in hairs (Tripathi *et al.*, 2021). Its leaves, arranged oppositely, are elliptical, oblong, or oblong-lanceolate in shape, with lightly toothed margins and a darker upper surface (Ghosh *et al.*, 2019). The plant produces small, densely clustered flowers in cymes about 1 cm in diameter. Its fruits are yellow, hairy capsules, 1-2 mm in diameter, each containing three angular, brown, wrinkled seeds (Pounikar *et al.*, 2013). Ecologically, *E. hirta* thrives in open grasslands, along roadsides, and on pathways, flourishing in warm, sunny environments (Adjeroh *et al.*, 2020).

Phytochemically, *E. hirta* is a rich source of bioactive compounds such as flavonoids, alkaloids, tannins, saponins, terpenoids, and polyphenols (Tripathi *et al.*, 2021). These compounds are largely responsible for the plants various medicinal properties, including its anti-inflammatory, antioxidant, antibacterial, and antiviral effects (Pounikar *et al.*, 2013). For example, its flavonoids exhibit potent antioxidant activities that protect cells from oxidative damage, while saponins and alkaloids contribute to the plant's antimicrobial effects, making it useful in treating infections caused by bacteria and viruses (Adjeroh *et al.*, 2020). The use of *E. hirta*, a well-known medicinal plant, has been extensively documented in traditional medicine practices across various cultures, particularly in Africa, Asia, and South America (Lako *et al.*, 2020; Mbwale *et al.*, 2024). Several methods are used to extract secondary metabolites from *E. hirta*, with solvent extraction using organic solvents like ethanol, n-cyclohexane, chloroform, and methanol (Ahmad *et al.*, 2017). The pharmacological properties of *E. hirta* have been extensively studied due to its broad range of biological activities, including anti-asthmatic, anticancer, anti-inflammatory, and antimicrobial effects. These properties highlight its potential to significantly contribute to global healthcare (Khursheed, 2022; Nyeem *et al.*, 2017). Despite its widespread use, there are gaps in understanding the plant's ethnobotanical applications, phytochemical composition, and pharmacological effects. This study aimed at consolidating the existing knowledge on its therapeutic value and chemical profile, bridging the gap between traditional uses and scientific research. By examining its ethnobotanical, phytochemical, and pharmacological aspects, the research can uncover the plant's full therapeutic potential, guide the development of new medicines, and highlight areas for further investigation.

## MATERIALS AND METHODS

### Search strategies and data extraction

This systematic review of literature was conducted according to the systematic review and meta-analysis (PRISMA) checklist (Chassagne *et al.*, 2021). We conducted a thorough literature search to evaluate relevant scientific literature. We systematically reviewed articles obtained from the Scopus scientific database, focusing on publications from 2000 to November 30, 2024 at 11: 30 AM. The search employed the keywords "*Euphorbia hirta* L." OR "lion ear" OR "TAWA-TAWA" OR "asthma plant" AND "ethnobotanical" OR "medicinal use" OR "traditional use" AND "phytochemicals" OR "secondary metabolites" OR "constituencies" OR "chemical composition" OR "bioactive compounds" OR "phytochemical profile" AND "pharmacological" OR "biological activity" OR "therapeutic potential" OR "medicinal properties". In addition to these keywords, we considered related variables such as the ethnobotanical applications, phytochemical composition, and pharmacological properties of *E. hirta* plant.

### Inclusion and exclusion criteria

This review includes only peer-reviewed research articles published in academic journals between the years 2000 and 2024, written in English. To ensure the quality and relevance of the selected literature, the review excludes non-English publications, articles published before 2000, and any material that is not a full peer-reviewed research article. Specifically, excluded sources comprise review articles, books, book chapters, book series, conference proceedings, reports, and abstracts. This strict inclusion and exclusion framework was applied to maintain a focus on original, high-quality research within the specified timeframe.

### Data collection

A total of 541 articles were initially identified from the Scopus database over a period of 15 years. The protocol and workflow for the selection of papers is shown in the PRISMA diagram (Fig. 1).

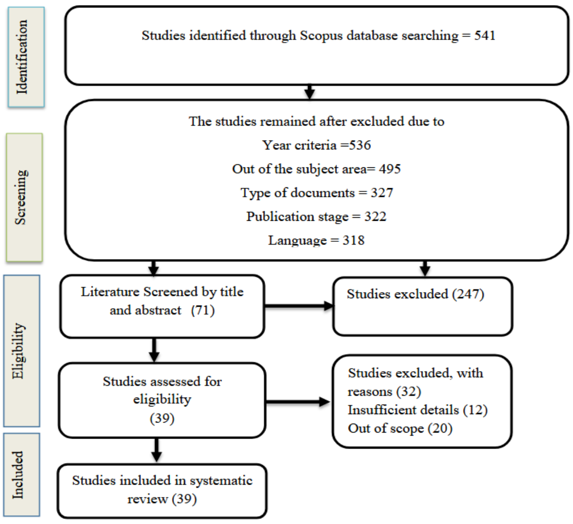


**Fig. 1.** Illustrating the selection process of literature included in the analysis

After excluding five studies based on publication year, 536 studies remained. Further filtering by subject area reduced this number to 495, and after considering the type of document, 327 studies were included. In the publication stage, five articles were excluded, leaving 322 studies. After removing non-English language articles, 318 studies remained. A manual review of titles and abstracts was then conducted, and 71 studies were selected for further eligibility testing. Upon careful review of the full texts, two studies were found to be out of scope and one lacked sufficient details, resulting in a final selection of 39 studies. These 39 studies were used to explore the ethnobotanical applications, phytochemical composition, and pharmacological properties of *E. hirta* plant.

## RESULTS AND DISCUSSION

### Characteristics of the included articles

The review analyzed 39 articles, revealing distinct trends in publication numbers over the years. From 2009 to 2015, the number of publications started at 1 in 2009 and gradually increased, reaching a peak of 2 in 2015 (Fig. 2). However, it is important to note that there were no publications in 2014, which may indicate a temporary stagnation or reduced research activity in that year. Between 2016 and 2019, there was a noticeable surge in publications, with a significant increase in 2016, followed by a peak of 4 publications in 2018. This increase may reflect heightened research interest or funding in the subject area during this period. However, in 2019, the number of publications dropped back to 1, suggesting a potential shift in focus or a decrease in available resources for research.

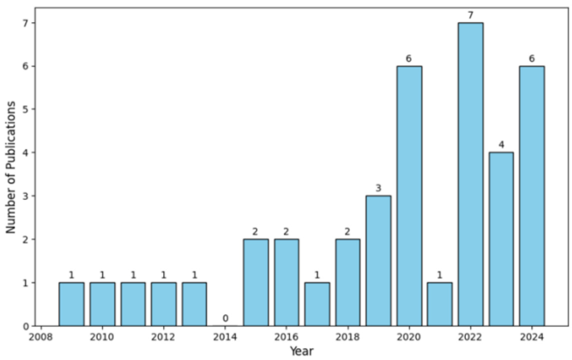


**Fig. 2.** Number of articles on *E. hirta* reviewed during the study

In 2020 and 2021, the number of publications increased, with a jump to 6 in 2020 (Fig. 2), potentially due to the effects of the COVID-19 pandemic, which might have driven greater research efforts in response to global challenges. While the number of publications slightly decreased to 5 in 2021, the overall trend remained positive, reflecting sustained interest in the topic. From 2022 to 2024, the trend continued to fluctuate: publications dropped to 2 in 2022, possibly reflecting changes in research priorities or external factors influencing scholarly output. However, there was a resurgence in 2023, with publications increasing to 6, indicating a renewed interest or breakthrough in the field. The projected peak of 7 publications in 2024 suggests ongoing growth and suggests that the research area is likely to continue attracting attention, with increasing momentum as new developments unfold. This fluctuation over time highlights the dynamic nature of research trends, which are often influenced by a variety of factors such as funding availability, global events, and shifts in academic priorities.

### Global trends in annual publication output

The research on medicinal plants, particularly *E. hirta,* has gained considerable attention in recent years, driven by an increasing interest in its ethnobotanical, phytochemical, and pharmacological properties.

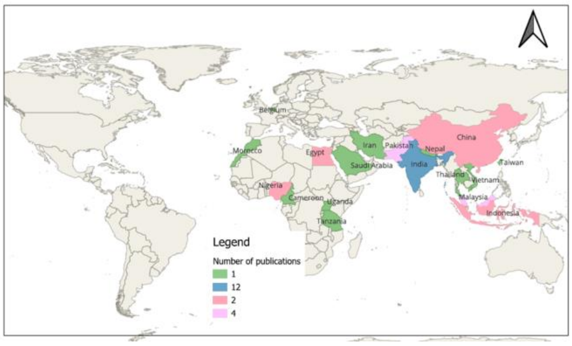


**Fig. 3.** Annual publications on *E. hirta* ethnobotanical uses, phytochemical profile, and pharmacological properties by country

By examining these aspects, the studies aim to uncover the plant's full therapeutic potential, facilitate the development of new medicines, and identify areas for future exploration. Publications on *E. hirta* span multiple countries, reflecting its widespread global significance. Notable contributions include studies from India (12 publications), Pakistan (4 publications), Malaysia (4 publications), and China (2 publications), along with research from other regions, such as Egypt (2), Indonesia (2), and Nigeria (2) (Fig. 3). Additional studies have been conducted in countries such as Cameroon, Iran, Morocco, Nepal, Saudi Arabia, Taiwan, Tanzania, Uganda, Thailand, and Vietnam, with one publication each from these regions. These global trends indicate a growing interest in *E. hirta* and its potential in modern and traditional medicine, paving the way for further interdisciplinary research and collaboration across borders.

**Table 1.** Medicinal uses of *E. hirta* in different parts of the world

| Part of *E. hirta* used | Types of solvents for extraction | Mode of preparation | Medicinal uses | Country | Reference |
|---|---|---|---|---|---|
| Leaves | Methanol extracts | Decoction | Males infertility | Nigeria | Oguejiofor *et al.*, 2021 |
| Leaves and flowers | Water, ethanol, petroleum ether, and chloroform | Infusion | Antimicrobial activity | India | Gupta *et al.*, 2018 |
| Leaves | Petroleum ether | Decoction | Wound healing | India | Abubakar, 2009 |
| Whole plant | Ethanol, methanol, chloroform and petroleum ether | Decoction | Antimicrobial and anticholinesterase approach | Nigeria | Lajoie *et al.*, 2022 Mahomoodally *et al.*, 2020 |
| Flower | Ethanolic and petroleum ether extracts | Decoction | Diabetes mellitus | India | Tripathi *et al.*, 2021 |
| Whole plant | Methanol, hexane and distilled water | Not mentioned | Antibacterial effectiveness | Nigeria | Abubakar, 2009 |
| Whole plant | Ethanolic extract | Decoction | Wound healing | Begum | Tuhin *et al.*, 2017 |
| Whole plant | Methanolic Ethanolic and water | Infusion/ decoction | UTI healing | Tanzania | Mbwale *et al.*, 2024 |
| Fresh leaves | Ethanolic extract | Infusion | Anticancer | India | Selvam *et al.*, 2019 |
| Whole plant material | N-hexane, chloroform, methanol, and water | Infusion | Inflammatory joint diseases | Malaysia | Chen *et al.*, 2015 |
| Whole plant (Fresh leaf, bud and stem) | Methanol, aqueous or ethanol | Infusion/ decoction | Human pathogenic bacteria | India | Kumari *et al.*, 2017; Mbwale *et al.*, 2025 |
| Whole plants | Hexane, ethyl acetate, and methanol | Decoction | Antioxidant activity | Morocco | Ouakil *et al.*, 2022 |
| Whole plant | Aqueous extracts | Decoction | Antibacterial activity | India | Bennet Rohan *et al.*, 2020 |
| Whole plant with flowers, stems and foliar tissue | Ethyl acetate, methanolic and water extracts | Infusion | Oxidative stress-related diseases | Ivory Coast | Mahomoodally *et al.*, 2020 |
| Whole plant | Ethyl acetate, n- butanol, methanol and ethanol. | Decoction | Antidiarrheal | China | Wu *et al.*, 2024 |
| The leaves | Ethyl acetate, ethanol, n-hexane, and n- butanol, chloroform | Decoction | Antibacterial | Egypt | Abdelkhalek *et al.*, 2018 |
| | Methanol extracts | Infusion | Antioxidant activity | Mexico | Larqué *et al.*, 2024 |
| Leaves | Petroleum ether | Not | Wound healing | India | Upadhyay *et al.*, 2014 |
| Stems, leaves, roots and flowers | Methanolic extracts | Infusion | Antibacterial and Antifungal Activity | Malaysia | Rajeh *et al.*, 2010 |
| Whole plant | Methanolic, n-hexane, ethyl acetate | Decoction | Ant- pressure | India | Sheliya *et al.*, 2010 |
| Whole plan | Methanol extraction | Infusion | Radiotoxicity in lymphocytes | India | Chakka *et al.*, 2023 |
| Leaves | Methanol extracts | Decoction | Acute toxicity impacts | Malaysia | Rajeh *et al.*, 2012 |

**Medicinal significance of *E. hirta* and its most commonly used parts**

The reviews found that parts of *E. hirta* are used for different medicinal purposes in different parts of the world, mainly in Asia and Africa. The parts used for treating several diseases, including male infertility, diabetes, Urinary tract infections, cancer, inflammation, diarrhea and wound healing due to the antimicrobial activity of the plant (Table 1). The whole plant has medicinal properties and the most commonly used parts of E. hirta, the utilized parts include leaves, flowers, stem and foliar tissue.

**Part of *E. hirta***

The analysis of medicinal usage of *E. hirta* reveals a clear preference for utilizing the whole plant, which accounts for the highest number of studies (14), compared to the leaves (6 studies) and flowers**,** which are rarely used (1 study) (Fig. 4). The statistical data support this disparity, with a mean of 7 and a high standard deviation of 6.56, indicating significant variation in how different parts are utilized. The maximum value (14) reflects the dominance of whole-plant use, while the minimum (1) highlights the limited interest in the flower. The interquartile range (3.5 to 10) further shows that most studies focus on the more commonly used parts, primarily the whole plant and leaves. This suggests that researchers and traditional medicine practitioners likely favor the holistic properties of the entire plant, possibly due to the broader spectrum of phytochemicals present throughout its tissues. Overall, the data demonstrates a strong bias toward whole-plant use in medicinal applications of *E. hirta*, with limited exploration of isolated parts like flowers.

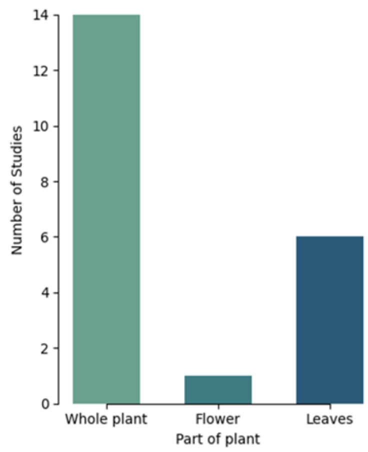


**Fig. 4.** Frequency of plant parts used in medicinal applications of *E. hirta*

The analysis of solvents commonly used for the extraction of *E. hirta* reveals a notable preference and variability among the seven solvents studied. With an average usage of approximately 6.7 studies per solvent and a standard deviation of 3.77, the data indicate moderate disparity in solvent selection.

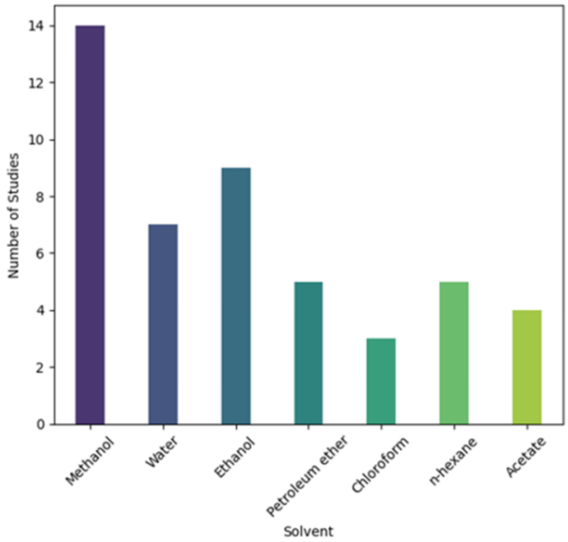


**Fig. 5.** Frequency of solvent used in the extraction of *E. hirta*

Methanol emerges as the most frequently employed solvent, appearing in 14 studies (Fig. 5), nearly double the overall mean, underscoring its dominant role in extraction protocols. This higher usage is likely due to methanol's strong polarity and excellent ability to dissolve a wide range of bioactive compounds, making it highly effective for phytochemical extraction. Ethanol and water also show considerable usage with 9 and 7 studies respectively (Fig. 5), reflecting their safety, availability, and compatibility with polar compounds. Conversely, solvents such as chloroform, acetate, and n-hexane are less frequently utilized, each appearing in fewer than six studies (Fig. 5). Their lower usage may be attributed to factors such as toxicity concerns (in the case of chloroform), limited polarity range, or lower efficiency in extracting the specific phytochemicals of interest in *E. hirta*. The distribution, reflected by quartiles ranging from 4.5 to 8, confirms that most solvents have moderate to low usage, suggesting that while a few solvents are preferred, there remains diversity in extraction approaches. This pattern emphasizes the importance of methanol and similar polar solvents in maximizing bioactive compound yield from *E. hirta*, while also indicating opportunities to explore the efficacy and safety profiles of less commonly used solvents in future research.

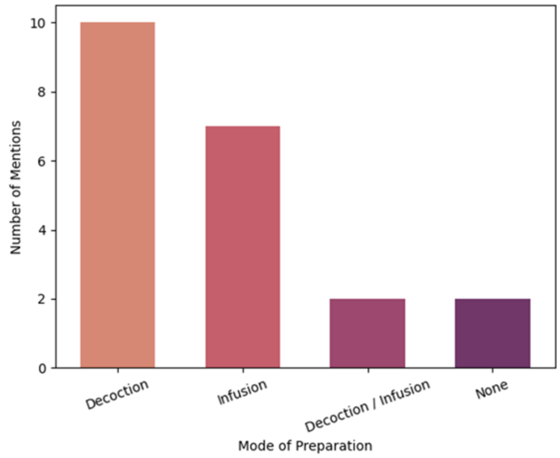


**Fig. 6.** Frequency of preparation methods used in the traditional medicine of *E. hirta*

The statistical analysis of the modes of preparation for traditional medicines derived from *E. hirta* shows a clear preference for certain methods over others. The mean usage frequency is 5.25, with a standard deviation of 3.95, indicating a moderate to high variability in how often each preparation method is used. Decoction is the most frequently employed method, appearing in 10 instances (Fig. 5), likely due to its effectiveness in extracting potent bioactive compounds from hard plant parts like roots, bark, or the whole plant. This method also benefits from its simplicity, low cost, and cultural familiarity, especially in regions with limited access to modern extraction technologies. Infusion, reported in 7 cases, is commonly used for more delicate plant materials such as leaves and flowers and is typically easier and faster to prepare than decoctions, though often yielding milder extracts. The combined method of decoction/infusion, along with the "None" category each reported only twice reflects significantly lower usage (Fig. 6). These lower frequencies may result from either less established traditional knowledge, lower efficacy, or underreporting in ethnobotanical documentation. In some cases, "None" may also indicate direct or raw application of the plant without prior processing. The minimum and maximum values (2 and 10) and interquartile range (2.0 to 7.75) reinforce the dominance of decoction while highlighting that other preparation methods are far less common. Overall, this pattern suggests that traditional healers favor water-based, heat-extraction methods, particularly decoctions, due to their proven effectiveness, safety, and accessibility, while alternative or mixed methods remain relatively niche or poorly documented.

**Traditional medicinal uses of *E. hirta* across different countries**

*Euphorbia hirta* has been widely utilized in traditional medicine across various countries, each using the plant to address specific health concerns based on local needs and practices. In China, it is commonly used for treating respiratory issues, such as asthma and bronchitis, due to its anti-asthmatic and anti-inflammatory properties (Zhang *et al.*, 2021). In Nepal, the plant is utilized to treat conditions like diarrhea, dysentery, and asthma, with its juice also being consumed for digestive disturbances, while the leaves are used topically for wound healing (Gharti *et al.*, 2024). Similarly, in Pakistan, *E. hirta* is employed for coughs, asthma, fever, and gastrointestinal disorders, as well as for its anti-inflammatory effects in treating joint pain (Mustafa *et al.*, 2023). In Belgium, it has been traditionally used for skin irritations and rashes, thanks to its mild antibacterial properties (Quetin-Leclercq and Hue, 2018). In Thailand, *E. hirta* is frequently used to treat colds, coughs, bronchitis, and ulcers, as well as to aid digestion (Ghosh *et al.*, 2019). In India, *E. hirta* is widely used in Ayurveda and traditional medicine to treat respiratory conditions, skin diseases, fever, and digestive disorders (Khursheed and Jain, 2022). In Taiwan, it is used in folk medicine to address asthma, coughs, and wounds, as well as to provide diuretic and anti-inflammatory effects (Akbar, 2020). In Vietnam, the plant is employed for respiratory issues such as asthma and bronchitis, along with its antimicrobial properties in wound treatment (Hue and Tram, 2020). Similarly, in Indonesia, *E. hirta* is used for asthma, coughs, and gastrointestinal problems, while in Malaysia, it is valued for treating fevers, respiratory conditions, and digestive issues (Puspitasari *et al.*, 2022; Soh *et al.*, 2017). In Nigeria, the plant plays a significant role in the treatment of malaria, asthma, and fever, as well as digestive ailments like diarrhea (Owolabi *et al.*, 2017). In Morocco, *E. hirta* is traditionally used to treat respiratory conditions and alleviate inflammation and pain from conditions like arthritis (Khamar *et al.*, 2021). In Cameroon, it is employed to treat wounds, ulcers, respiratory disorders, and as an anti-inflammatory agent in local remedies (Monga *et al.*, 2011). Similarly, in Uganda and Tanzania, the plant is used for treating malaria, respiratory infections, fever, diarrhea, and skin conditions (Mbwale *et al.*, 2025; Okullo *et al.*, 2010). In Saudi Arabia, *E. hirta* is used in traditional medicine to treat ailments such as asthma, cough, and digestive issues, as well as to promote wound healing (Al-Yahya *et al.*, 2015). In Iran, the plant is employed in folk medicine for treating respiratory conditions, digestive disturbances, and inflammation (Mansouri *et al.*, 2013). These diverse applications across regions highlight *E. hirta*'s extensive medicinal significance, showcasing its valuable role in folk medicine and its global use as a natural remedy for various health issue.

**Ethnopharmacological significance of *E. hirta***

The ethnopharmacological significance of *E. hirta* lies in its wide-ranging therapeutic properties, which have been recognized in traditional medicine across various cultures. The plant is particularly valued for its anti-inflammatory, antiasthmatic, antimicrobial, and antidiabetic effects, making it a critical component in the treatment of respiratory conditions, infections, and chronic diseases. Studies have shown that *E. hirta* contains bioactive compounds such as flavonoids, alkaloids, saponins, and tannins, which contribute to its medicinal properties (Khursheed and Jain, 20222; Puspitasari *et al.*, 2022). In addition to its respiratory benefits, *E. hirta* has demonstrated significant antimicrobial activity against various pathogens, including bacteria and fungi, further solidifying its use in treating infections (Gupta *et al.*, 2018). Ethnopharmacological research also highlights the plant's role in managing gastrointestinal disorders, with evidence supporting its antidiarrheal and antiulcer properties (Ibrahim *et al.*, 2024).

Moreover, the plant's role in addressing skin conditions, such as wounds and rashes, is widely documented, with local communities using it topically for its antiseptic and healing properties (Mbwale *et al.*, 2024; Vishwakarma *et al.*, 2024). Thus, *E. hirta* plays a significant role in ethnopharmacology, bridging the gap between traditional medicinal practices and modern pharmacological research, which validates its broad therapeutic potential.

**Folk medicine and regional applications of *E. hirta***

*Euphorbia. hirta* holds a prominent place in folk medicine across various regions, where it is utilized for a wide range of health conditions. In many African countries, including Nigeria and Cameroon, the plant is commonly used to treat malaria, respiratory infections, and digestive issues, with both the leaves and whole plant being employed in various preparations (Ojediran *et al.*, 2024; Owolabi *et al.*, 2017; Monga *et al.*, 2011). In India, *E. hirta* is a staple in Ayurvedic practices, where it is used to treat asthma, bronchitis, and skin diseases, often as a decoction or topical application (Khursheed and Jain, 2022; dev Sharma *et al.*, 2023). In Southeast Asia, including Thailand and Indonesia, the plant is valued for its ability to treat coughs, fever, and gastrointestinal problems, and it is frequently used as a poultice for skin conditions like wounds and rashes (Chandran *et al.*, 2006; Ghosh *et al.*, 2019; Soejarto *et al.*, 1986).

In South America and West Africa, the plant is widely recognized for its anti-inflammatory, analgesic, and antimicrobial properties, and is also used to treat respiratory problems (Nyeem *et al.*, 2017). In East African countries such as Tanzania and Uganda, it is commonly used in traditional medicine to treat a range of conditions, including urinary tract infections (UTIs), malaria, colic in children, typhoid, and to promote wound healing (Hamill *et al.*, 2000; (Mbwale *et al.*, 2024). The

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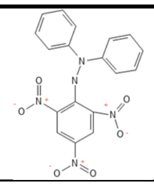
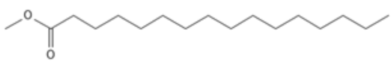
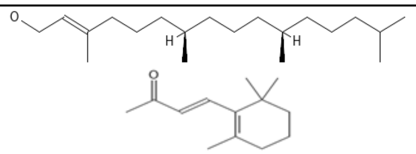
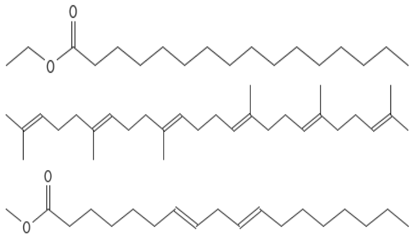
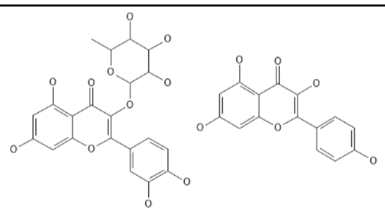
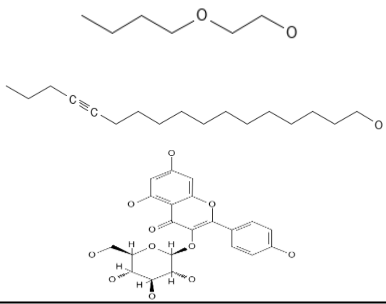
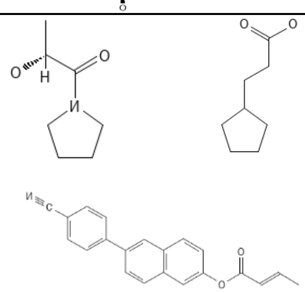
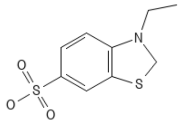
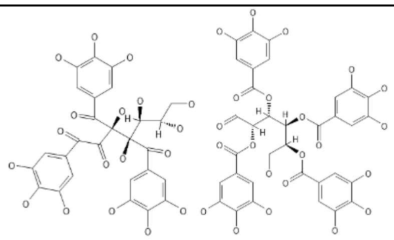
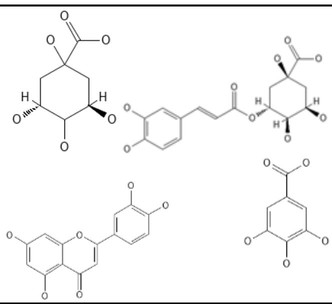
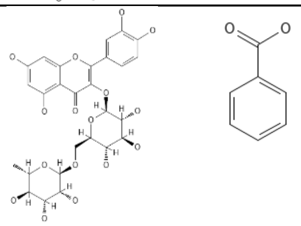
regional use of *E. hirta* is a testament to its versatility, with various communities relying on its natural healing properties for both internal and external applications. This widespread use across cultures underscores the plant's significant role in local healthcare systems, particularly in areas where access to modern pharmaceuticals may be limited.

**Table 2.** Major bioactive compounds in E. hirta as reported in some previous studies

| No | Name of the compound | Pharmacological activities | The diagram of compound | Reference |
|---|---|---|---|---|
| 1 | 1, 1-diphenyl-2-picryl-hydrazyl | Antioxidant, antitumor, antiviral, and antiparasitic agent. Commonly used to measure free radical scavenging activity. |  | Al-Mutairi *et al.*, 2019; Patel and Shirsat, 2024 |
| 2 | Hexadecanoic acid methyl ester | Anti-arthritic, anti-ulcer, anti-inflammatory, diuretic, hepatoprotective, neuroprotective activities. |  | De *et al.*, 2023; Gupta *et al.*, 2023; Shaaban *et al.*, 2021 |
| 3 | Phytol, Trans-.beta.-Ionone | Phytol: antioxidant, anti-aging, enzyme inhibition. Trans-β-Ionone: neuroprotective, anticancer, antioxidant. |  | Mbwale *et al.*, 2025; Zhang *et al.*, 2025; Kadry *et al.*, 2009 |
| 4 | Ethyl palmitate, squalene 7, 10-octadecadienoic acid methyl ester. | Ethyl palmitate: anticancer, antibacterial, antifungal; Squalene: antioxidant, chemopreventive; Fatty acid ester: anti-inflammatory. |  | Xia *et al.*, 2018; Szczepańska *et al.*, 2023 |
| 5 | Quercetin 3-O-rhamnose, Kaempferol. | Antiviral, antibacterial, antifungal; Quercetin-rhamnose: antimicrobial target; Kaempferol: antioxidant, anti-inflammatory. |  | Onyeka *et al.*, 2020; Wu *et al.*, 2024; Menon and Thakker, 2020; Widyananda *et al.*, 2023 |
| 6 | Myricitrin, 4', 5, 7-tetrahydroxyflavone (kaempferol). 2-butoxy ethanol, decane, caryophyllene, 13-heptadecyn-1-ol | Free radical scavenging (antioxidant), antibacterial, antifungal, microbial degradation activity |  | Kripa and Kanna, 2022; Alsaffar *et al.*, 2024 |
| 7 | 2-hydroxy-1-1'-pyrrolidiyl-1-buten-3-one, and 3-cyclopentylpropionic acid, and 6-4-cyanophenyl-2-naphthalenyl ester. | Cytotoxicity, antiproliferative (anticancer), antimicrobial activity. |  | Sharma *et al.*, 2023; Aljubiri *et al.*, 2021; Ramond *et al.*, 2022 |

| | | | | |
|---|---|---|---|---|
| 8 | 3-ethylbenzothiazoline-6-sulfonic acid | Commonly used to measure total antioxidant capacity (TAC); potent antioxidant indicator. |  | Mahomoodally *et al.*, 2020; Ji *et al.*, 2021; Martiani *et al.*, 2024 |
| 9 | Tri-O-galloyl-glucose isomers, tetra-O-galloyl-glucose isomers, | Antibacterial (S. aureus, E. coli), antifungal, antidiabetic, neuroprotective, anticancer. |  | Mekam *et al.*, 2019; Burico *et al.*, 2022; Ivanov *et al.*, 2023 |
| 10 | Quinic acid, gallic acid, luteolin, and chlorogenic acid | Antioxidant, antibacterial, antifungal; Luteolin also acts as anti-inflammatory and neuroprotective agent. |  | Gopi *et al.*, 2015; Lu *et al.*, 2021; Ercan and Doğru, 2022; Wang *et al.*, 2022 |
| 12 | Benzoic acid and rutin | Benzoic acid: used in antiseptics, syrups, oral meds; Rutin: skin health, antidiabetic, vascular protective. |  | Ali *et al.*, 2020; Mao *et al.*, 2019; Imani *et al.*, 2021 |

**Phytochemical profile of *E. hirta***

The phytochemical profile of *E. hirta* is diverse and contributes to its broad range of medicinal properties. Various studies have identified a wide array of bioactive compounds in the plant, including alkaloids, flavonoids, tannins, saponins, glycosides, and terpenoids, which play a crucial role in its therapeutic effects (Tripathi *et al.*, 2021; Kumar *et al.*, 2010; Edrees, 2019; Huang *et al.*, 2012). These compounds are responsible for the plant's anti-inflammatory, antimicrobial, antioxidant, antidiabetic, and antiasthmatic activities, making it a valuable resource in both traditional and modern medicine. The presence of flavonoids such as quercetin and kaempferol, alkaloids like nicotine and ephedrine, and saponins has been extensively documented in scientific literature (Khursheed and Jain, 2022; Mbwale *et al.*, 2025). This phytochemical diversity not only enhances the plant's medicinal value but also makes it a subject of interest for pharmacological research. Table 2 presents the structures of various phytochemicals, offering a visual representation of the plant's intricate chemical composition.

Additionally, citations from relevant studies are included to support the identification and highlight the significance of these phytochemicals for further reference.

**Methods of extraction and identification of compounds from *E. hirta***

The extraction and identification of bioactive compounds from *E. hirta* are crucial steps in understanding its medicinal potential. Several methods have been employed to extract compounds from the plant, with the aim of obtaining the maximum yield of active ingredients. Common solvents used in the extraction process include ethanol, methanol, chloroform, and water (Anitha *et al.*, 2014; Oseni *et al.*, 2019; Mbwale *et al.*, 2025), with ethanol and methanol proving particularly effective for isolating a wide range of bioactive compounds, such as flavonoids, alkaloids, and tannins (Khursheed and Jain, 2022). One widely used extraction method is maceration, in which the plant material is soaked in the solvent for a specified period, ensuring the efficient extraction of compounds (Alamgir, 2017; Abubakar *et al.*, 2020; Stéphane *et al.*, 2021). These methods help obtain concentrated extracts that contain the plant's therapeutic compounds, providing a foundation for subsequent analysis.

The studies reviewed indicate that once the extract is obtained, the identification of compounds is performed using advanced techniques such as Thin Layer Chromatography (TLC), High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), and Nuclear Magnetic Resonance (NMR) spectroscopy (Verma, 2021; Patyra*et al.*, 2022; Aljubiri *et al.*, 2021). TLC is commonly employed for the preliminary separation of compounds, while HPLC and GC-MS are more advanced techniques that enable the precise identification and quantification of individual bioactive compounds (Parys *et al.*, 2022; Kiani *et al.*, 2022). NMR spectroscopy is used to confirm the molecular structures of these compounds, offering detailed insights into their chemical composition (Deborde *et al.*, 2017). These methods provide valuable information about the chemical constituents of *E. hirta*, establishing a clear connection between its phytochemical profile and its pharmacological activities. The identification of these compounds through modern analytical techniques is essential for validating the plant's medicinal properties and facilitating its integration into pharmaceutical applications.

## Pharmacological properties of *E.hirta*

*Euphorbia hirta* exhibits a wide range of pharmacological properties, which have been widely studied for their therapeutic potential. It is well known for its anti-inflammatory, antiasthmatic, antimicrobial, antioxidant, antidiabetic, and antimalarial effects (Nkemzi *et al.*, 2022; Pradhan *et al.*, 2024). Studies have shown that the plant's bioactive compounds, such as flavonoids, alkaloids, saponins, and tannins, contribute to these properties (Khursheed and Jain, 2022; Mbwale *et al.*, 2025). *E. hirta* has demonstrated significant antimicrobial activity against various bacteria and fungi, making it valuable in treating infections (Nguyen *et al.*, 2012). Its anti-diabetic properties have also been highlighted, with the plant showing potential in regulating blood glucose levels (Muema *et al.*, 2023). Furthermore, the plant has shown promise in managing asthma and other respiratory disorders due to its bronchodilatory and anti-inflammatory effects (Akbar, 2020). These pharmacological properties underscore the plant's significant role in both traditional and modern medicine.

## Toxicological and safety or adverse effects of *E. hirta*

Although *E. hirta* is widely recognized for its therapeutic properties, its toxicological profile and potential adverse effects must also be considered. Studies indicate that higher doses may cause irritation, allergic reactions, and toxicity in humans and animals, with the compounds in latex potentially leading to skin rashes, blistering, and gastrointestinal discomfort if ingested in large quantities (Ghosh *et al.*, 2019; Panzu *et al.*, 2020; Khursheed and Jain, 2022; Chekecha, 2023). Additionally, *E. hirta* has been reported to cause liver toxicity in some animal studies when consumed excessively, suggesting the need for caution regarding dosage (Rajeh *et al.*, 2012; Idowu *et al.*, 2019; Nyeem *et al.*, 2017). In high doses, the plant may also exhibit toxic effects on the kidneys and central nervous system, highlighting the importance of proper medicinal dosages and preparation methods (Bhat *et al.*, 2019). While *E. hirta* has shown promise as a medicinal plant, its safety profile requires further investigation to fully understand its potential risks and ensure its safe use in healthcare applications.

## Potential toxicity of *E. hirta* or adverse effects

The potential toxicity and adverse effects of *E. hirta* have been reported in several studies, raising concerns about its safety when used improperly or in excessive amounts. One of the most notable toxic effects is skin irritation caused by the latex of the plant, which can result in dermatitis, rashes, or even blistering upon direct contact (Das, 2020; Malik *et al.*, 2021; Anand *et al.*, 2022; Bhatia *et al.*, 2024).

Additionally, ingesting large quantities of *E. hirta* has been linked to gastrointestinal disturbances such as nausea, vomiting, and diarrhea. The latex contains compounds like diterpenoids and esters that are considered toxic in high concentrations (Idowu *et al.*, 2019). It is particularly important to note that while the plant is widely used in traditional medicine, unregulated usage or improper handling can lead to these adverse effects, especially when administered in high doses.

In animal studies, *E. hirta* has been shown to cause liver and kidney toxicity when consumed in excessive amounts, leading to concerns about its long-term safety (Tuhin *et al.*, 2017). High doses of the plant extract have also been associated with central nervous system effects, including sedation and changes in behavior, suggesting that caution is necessary when using it for medicinal purposes. Despite its beneficial therapeutic effects, these toxicological findings underscore the need for careful dosage and proper preparation methods to minimize potential risks. As highlighted in various studies, further research into the plant's safety profile and toxicology is essential to ensure that its medicinal applications are both effective and safe for human use.

**Dosage recommendations and safety concerns on the use of *E. hirta***

When using *E. hirta* for medicinal purposes, it is crucial to adhere to recommended dosages to avoid potential toxicity and adverse effects. Traditional usage often involves the administration of the plant in the form of decoctions, tinctures, or topical applications, with doses varying based on the condition being treated. However, specific dosage guidelines are not always standardized, and excessive consumption of *E. hirta*, particularly its latex, can lead to skin irritation, gastrointestinal discomfort, and in extreme cases, liver and kidney toxicity (Ghosh *et al.*, 2019; Panzu *et al.*, 2020; Khursheed and Jain, 2022; Chekecha, 2023; Ghosh *et al.*, 2019). To minimize safety concerns, it is recommended that users begin with lower doses, particularly when using the plant in oral form, and gradually increase the dosage while monitoring for any adverse reactions. Additionally, due to the plant's potential toxic effects when taken in large amounts, it is advisable to consult with a healthcare professional, particularly for individuals with preexisting medical conditions, such as liver or kidney disorders. While *E. hirta* has shown promising therapeutic effects, more research is needed to establish specific dosage recommendations and safety protocols to ensure its safe and effective use in both traditional and modern medical practices.

**Molecular mechanisms behind its pharmacological effects of *E. hirta***

The pharmacological effects of *E. hirta* are attributed to its diverse bioactive compounds, which exert their therapeutic actions through various molecular mechanisms. Flavonoids, alkaloids, saponins, and tannins found in *E. hirta* are key contributors to its biological activities. For example, flavonoids like quercetin and kaempferol are known to possess potent anti-inflammatory and antioxidant properties, which help modulate the production of pro-inflammatory cytokines and reactive oxygen species (ROS) by inhibiting signaling pathways such as NF-kB (nuclear factor kappa B) and MAPK (mitogen-activated protein kinase) pathways (Tung *et al.*, 2023; Zahra *et al.*, 2024; Chakraborty *et al.*, 2024). Additionally, alkaloids like nicotine and ephedrine found in the plant are thought to act as bronchodilators, aiding in the treatment of respiratory conditions like asthma by stimulating beta-adrenergic receptors, thereby relaxing bronchial smooth muscles and improving airflow (Bhatia *et al.*, 2024). The plant's antimicrobial activity is primarily attributed to its tannins and saponins, which disrupt the integrity of bacterial cell membranes and inhibit the growth of pathogenic microorganisms (Othman *et al.*, 2019).

Furthermore, *E. hirta* has demonstrated anti-diabetic effects through the inhibition of alpha-glucosidase, which slows the breakdown of carbohydrates and reduces blood glucose levels (Oulahal *et al.*, 2022).

These molecular mechanisms underscore the multifaceted therapeutic potential of *E. hirta* and its ability to address a wide range of health conditions through modulation of various biological pathways.

## CONCLUSION

*Euphorbia hirta* has demonstrated significant ethnobotanical, pharmacological, and therapeutic potential, owing to its diverse array of bioactive compounds, including flavonoids, alkaloids, tannins, saponins, and terpenoids. These compounds contribute to its broad spectrum of medicinal properties, including anti-inflammatory, antimicrobial, anti-diabetic, anti-asthmatic, and antimalarial activities.

Traditional uses of *E. hirta* across different regions of the world underscore its importance in folk medicine for treating a wide range of health issues, from respiratory conditions to digestive and skin disorders. The plant's molecular mechanisms, including modulation of oxidative stress, inhibition of inflammatory cytokines, and interaction with cellular pathways such as the NF-kB and MAPK signaling pathways, further support its therapeutic efficacy.

However, despite the promising therapeutic effects, certain gaps in the current knowledge remain. The potential toxicity of *E. hirta* especially from its latex and in high doses requires more detailed exploration to better understand its safety profile and adverse effects. While several studies have highlighted the plant's broad-spectrum benefits, standardized dosage recommendations and precise safety guidelines are still lacking. Future research should focus on identifying and characterizing specific bioactive compounds responsible for its pharmacological activities, as well as determining optimal dosages and safety limits for human use. Additionally, there is a need for clinical studies to validate the efficacy and safety of *E. hirta* in modern medical applications. Investigating the plant's interaction with conventional medicines and its long-term use will also be crucial in integrating it into contemporary healthcare systems. Thus, *E. hirta* presents an exciting avenue for future research, bridging the gap between traditional knowledge and modern therapeutic practices.

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## REFERENCES

**Abubakar EM.** 2009. Antibacterial activity of crude extracts of *Euphorbia hirta* against some bacteria associated with enteric infections. Journal of Medicinal Plants Research **3**(7), 498–505.

**Adjeroh LA, Nwachukwu MO, Abara PN, Nnokwe JC, Azorji JN, Osinomumu IO.** 2020. Phytochemical screening and antibacterial/antifungal activities of root and shoot extracts of *Euphorbia hirta* (asthma weed). International Journal of Tropical Disease & Health **41**(6), 1–10. https://doi.org/10.9734/ijtdh/2020/41i630281

**Ahmad W, Singh S, Kumar S.** 2017. Phytochemical screening and antimicrobial study of *Euphorbia hirta* extracts. Journal of Medicinal Plants Studies **5**(2), 183–186.

**Akbar S.** 2020. *Euphorbia hirta* L.; *Chamaesyce hirta* (L.) Millsp. (Euphorbiaceae). In Handbook of 200 medicinal plants, 889–898. Springer International Publishing. https://doi.org/10.1007/978-3-030-16807-0_95

**Alamgir ANM.** 2017. Herbal drugs: their collection, preservation, and preparation; evaluation, quality control, and standardization of herbal drugs. In Therapeutic use of medicinal plants and their extracts, volume 1: pharmacognosy, 453–495. Springer International Publishing. https://doi.org/10.1007/978-3-319-63862-1_10

**Ali MZ, Mehmood MH, Saleem M, Gilani A-H.** 2020. The use of *Euphorbia hirta* L. (Euphorbiaceae) in diarrhea and constipation involves calcium antagonism and cholinergic mechanisms. BMC Complementary Medicine and Therapies **20**(1), 14. https://doi.org/10.1186/s12906-019-2793-0

**Aljubiri SM, Mahmoud K, Mahgoub SA, Almansour AI, Shaker KH.** 2021. Bioactive compounds from *Euphorbia schimperiana* with cytotoxic and antibacterial activities. South African Journal of Botany **141**, 357–366.

**Al-Mutairi KA, Mobin M, Khan MN.** 2019. A comparison of bioactive constituents and *in vitro* antioxidant potential of asthma weed (*Euphorbia hirta*) with those of other anti-asthmatic plants growing in Tabuk region, Saudi Arabia. Applied Ecology & Environmental Research **17**(6). https://aloki.hu/pdf/1706_1398914000.pdf

**Alsaffar D, Alhawarri MB, Yaseen A, Hanapi NA, Yusof SR, Dianita R, Aziz NHKA.** 2024. Isolation, structural characterisation and wound healing activity of flavonoid and its glycoside from *Euphorbia hirta* L. methanolic extract. Iraqi Journal of Pharmaceutical Sciences **33**(3), 89–105.

**Bhat SA, Mir SA, Maqbool M, Bhat AU, Masoodi MH.** 2019. Evaluation of phytochemical, antioxidant, and in vitro antidiarrhoeal activity of *Euphorbia hirta*. Journal of Drug Delivery and Therapeutics **9**(1), Article 1-s. https://doi.org/10.22270/jddt.v9i1-s.2352

**Bhatia M, Chaudhary J, Jain A, Sonam, Dhingra A, Chopra B.** 2024. A recent update on ayurvedic anti-asthmatic formulations: highlighting the role of major anti-asthmatic plants. Current Traditional Medicine **10**(6). https://doi.org/10.2174/2215083810666230622111859

**Burico M, Fodaroni G, Flamini E, Ascani N, Proietti G, Tamimi S, Quintiero CM, Massa L, Gianni M, Mattoli L.** 2022. Metabolomic fingerprint of *Hamamelis virginiana* L. gallotannins by suspect screening analysis with UHPLC-qToF and their semiquantitative evaluation. Journal of Mass Spectrometry **57**(8), e4878. https://doi.org/10.1002/jms.4878

**Chekecha C.** 2023. Ethnobotany and antibacterial effects of golden berry (*Physalis peruviana* L.) on *Salmonella typhi* in Mbeya rural district, Tanzania. MSc thesis, Nelson Mandela African Institution of Science and Technology. https://doi.org/10.58694/20.500.12479/2149

**Chen J, Er H, Mohamed S, Chen Y.** 2015. In vitro anti-inflammatory activity of fractionated *Euphorbia hirta* aqueous extract on rabbit synovial fibroblasts. Biomedical Journal **38**(4). http://biomedj.cgu.edu.tw/pdfs/2015/38/4/images/BiomedJ_2015_38_4_301_151031.pdf

**De M, Sharma L, Acharya C.** 2023. A comprehensive chemical characterization of leaves of five potential medicinal plants in Paschim Medinipur District, West Bengal, India. International Journal of Experimental Research Review **36**, 20–36.

**Deborde C, Moing A, Roch L, Jacob D, Rolin D, Giraudeau P.** 2017. Plant metabolism as studied by NMR spectroscopy. Progress in Nuclear Magnetic Resonance Spectroscopy **102**, 61–97.

**Dev Sharma A, Kaur I, Chuhan A, Kumar S, Singh N.** 2023. Phytochemical profile, in vitro antioxidant, antidiabetic and anti-inflammatory activities of traditionally used *Euphorbia hirta* (L.) growing under wild conditions of Northern Punjab. Drug Analytical Research **7**(1), 27–40.

**Ercan L, Doğru M.** 2022. Antioxidant and antimicrobial capacity of quinic acid. Bitlis Eren Üniversitesi Fen Bilimleri Dergisi **11**(4), 1018–1025.

**Gharti SD, Nag P, Magar GT, Singh AK.** 2024. Ethnomedicinal plants used in Tharu community: a case study of Rapti Sonari, Western Nepal. PhytoTalks **1**(2), 143–156.

**Ghosh P, Ghosh C, Das S, Das C, Mandal S, Chatterjee S.** 2019. Botanical description, phytochemical constituents and pharmacological properties of *Euphorbia hirta* Linn.: a review. International Journal of Health Sciences and Research **9**(3), 273–286.

**Gopi K, Renu K, Vishwanath BS, Jayaraman G.** 2015. Protective effect of *Euphorbia hirta* and its components against snake venom-induced lethality. Journal of Ethnopharmacology **165**, 180–190.

**Gupta D, Kumar M, Gupta V.** 2018. An in vitro investigation of antimicrobial efficacy of *Euphorbia hirta* and *Murraya koenigii* against selected pathogenic microorganisms. Asian Journal of Pharmaceutical and Clinical Research **11**(5), 359–363.

**Gupta V, Tyagi S, Tripathi R.** 2023. Hexadecanoic acid methyl ester, a potent hepatoprotective compound in leaves of *Pistia stratiotes* L. The Applied Biology & Chemistry Journal **4**(4), 118–120.

**Hamill FA, Apio S, Mubiru NK, Mosango M, Bukenya-Ziraba R, Maganyi OW, Soejarto DD.** 2000. Traditional herbal drugs of southern Uganda. Journal of Ethnopharmacology **70**(3), 281–300.

**Huang L, Chen S, Yang M.** 2012. *Euphorbia hirta* (Feiyangcao): A review on its ethnopharmacology, phytochemistry and pharmacology. Journal of Medicinal Plants Research **6**(39), 5176–5185.

**Hue BTB, Tram NTT.** 2020. Chemical constituents from n-hexane and ethyl acetate extracts of *Euphorbia hirta* L. grown in Vietnam. IOP Conference Series: Materials Science and Engineering **736**(2), 022083. https://iopscience.iop.org/article/10.1088/1757-899X/736/2/022083

**Ibrahim AD, Salisu BD, Mukhtar GL, Lawal I.** 2024. Phytochemistry and biological activities of ethnopharmacological plants widely used in the treatment of peptic ulcer diseases. UMYU Journal of Microbiology Research **9**(3), 518–549.

**Imani A, Maleki N, Bohlouli S, Kouhsoltani M, Sharifi S, Maleki Dizaj S.** 2021. Molecular mechanisms of anticancer effect of rutin. Phytotherapy Research **35**(5), 2500–2513. https://doi.org/10.1002/ptr.6977

**Ivanov I, Vasileva A, Tasheva D, Dimitrova M.** 2023. Isolation and characterization of natural inhibitors of post-proline specific peptidases from the leaves of *Cotinus coggygria* Scop. Journal of Ethnopharmacology **314**, 116508.

**Ji F, Guo Y, Wang M, Wu Z, Shi Y, Zhao X, Wang H, Feng X, Zhao G.** 2021. Excited-state electronic structures and photochemistry of different oxidation states of ABTS. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy **253**, 119503.

**Kadry H, Shoala S, Gindi OE, Sleem AA, Mosharrafa S, Kassem M.** 2009. Chemical characterization of the lipophilic fraction of *Livistona decipiens* and *Livistona chinensis* fruit pulps and assessment of their anti-hyperlipidemic and anti-ulcer activities. Natural Product Communications **4**(2), 1934578X0900400220. https://doi.org/10.1177/1934578X0900400220

**Khamar H, Benkhnigue O, Zidane L.** 2021. *Euphorbia hirta* (Euphorbiaceae): a new naturalized xenophyte in the vascular flora of Morocco. Flora Mediterranea **31**. https://semanticscholar.org/bb10/f1eaa1fa94ac8383516e7945539bf4df84f3.pdf

**Khan MSA, Ahmad I.** 2019. Herbal medicine: current trends and future prospects. In New look to phytomedicine, 3–13. Elsevier. https://www.sciencedirect.com/science/article/pii/B978012814619400001X

**Khursheed A, Jain V.** 2022. *Euphorbia hirta* as a gold mine of high-value phytochemicals: a comprehensive review of its pharmacological activities and possible role against SARS-CoV-2. Biomedical Research and Therapy **9**(2), 4930–4949.

**Kripa N, Kanna RK.** 2022. *Euphorbia hirta* leaves extracts for removal of warts and skin diseases. Journal of Natural Remedies, 99–103.

**Lajoie L, Fabiano-Tixier A-S, Chemat F.** 2022. Water as green solvent: methods of solubilisation and extraction of natural products—past, present and future solutions. Pharmaceuticals **15**(12), 1507.

**Lako JDW, Sube KLL, Lumori CSG, Yengkopiong JP, Utong JAM, Binyason SA, Ngerja YSL, Moilinga MK, Lado TF, Kheiralla AH.** 2020. Diversity and distribution of medicinal plants in the Republic of South Sudan. World Journal of Advanced Research and Reviews **7**(1), 018–031.

**Lu L, Zhao Y, Yi G, Li M, Liao L, Yang C, Cho C, Zhang B, Zhu J, Zou K, Cheng Q.** 2021. Quinic acid: a potential antibiofilm agent against clinical resistant *Pseudomonas aeruginosa*. Chinese Medicine **16**(1), 72. https://doi.org/10.1186/s13020-021-00481-8

**Mahomoodally MF, Dall'Acqua S, Sinan KI, Sut S, Ferrarese I, Etienne OK, Sadeer NB, Ak G, Zengin G.** 2020. Phenolic compounds analysis of three *Euphorbia* species by LC-DAD-MSn and their biological properties. Journal of Pharmaceutical and Biomedical Analysis **189**, 113477.

**Maldonado Miranda JJ.** 2021. Medicinal plants and their traditional uses in different locations. Phytomedicine, 207–223.

**Mao X, Yang Q, Chen D, Yu B, He J.** 2019. Benzoic acid used as food and feed additives can regulate gut functions. BioMed Research International **2019**, 5721585. https://doi.org/10.1155/2019/5721585

**Martiani I, Rustamsyah A, Puspitasari TEE, Sujana D.** 2024. Comparison of ABTS and DPPH assays to measure antioxidant activity of ethanol extract of red alga (*Gelidium* sp.). Jurnal Ilmiah Farmako Bahari **15**(1), 106–112.

**Mbwale I, Giliba RA, Kisula L, Kemboi D.** 2025. Unlocking nature's pharmacy: *Euphorbia hirta* (L.) as a potent defense against *Escherichia coli* and *Klebsiella pneumoniae* infections in Tanzania. South African Journal of Botany **177**, 1–13. https://doi.org/10.1016/j.sajb.2024.11.036

**Mbwale I, Kisula L, Giliba RA.** 2024. Exploring the ecological and ethnobotanical dimensions of *Euphorbia hirta* (L.): insights from the Maasai and Meru ethnic groups in Tanzania. Human Ecology **52**(5), 1023–1034. https://doi.org/10.1007/s10745-024-00550-0

**Mekam PN, Martini S, Nguefack J, Tagliazucchi D, Stefani E.** 2019. Phenolic compounds profile of water and ethanol extracts of *Euphorbia hirta* L. leaves showing antioxidant and antifungal properties. South African Journal of Botany **127**, 319–332.

**Menon S, Thakker J.** 2020. Bio-efficacy of *Euphorbia hirta* L. on the growth and antioxidant activity of *Cicer arietinum* L. Plant Archives **20**(1), 3290–3294.

**Muema FW, Nanjala C, Oulo MA, Wangchuk P.** 2023. Phytochemical content and antidiabetic properties of commonly used antidiabetic medicinal plants of Kenya. Molecules **28**(20), 7202.

**Mustafa A, Hanif U, Sardar AA, Jan HA.** 2023. Ethnomedicinal study of medicinal plants used by the population of Taunsa Sharif, Dera Ghazi Khan, Punjab, Pakistan. Ethnobotany Research and Applications **26**, 1–27.

**Nick IM.** 2022. Book review: Charles Darwin's barnacle and David Bowie's spider: how scientific names celebrate adventurers, heroes, and even a few scoundrels. Names: A Journal of Onomastics. https://ans-names.pitt.edu/ans/article/view/2441

**Nyeem MAB, Haque MS, Akramuzzaman M, Siddika R, Sultana S, Islam BR.** 2017. *Euphorbia hirta* Linn., a wonderful miracle plant of Mediterranean region: a review. Journal of Medicinal Plants Studies **5**(3), 170–175.

**Ofor EU.** 2007. Characterization of essential oils and methanolic extracts of selected medicinal plants used for the management of asthma in alternative medicine. PhD thesis, University of Lagos. https://ir.unilag.edu.ng/handle/123456789/3212

**Oguejiofor CF, Onyejekwe OB, Onwuzurike OI.** 2021. In vitro immobilizing and spermicidal effects of methanol leaf extract of *Euphorbia hirta* Linn. (Euphorbiaceae) on caprine spermatozoa. Tropical Journal of Pharmaceutical Research **20**(2), 329–336.

**Ojediran GO, Ojediran O, Titilawo OY, Shehu Z, Titilawo MA.** 2024. Fractionation and characterization of natural antibacterial compounds from *Euphorbia hirta* Linn. (asthma plant). BIMA Journal of Science and Technology **8**(1B), 170–179.

**Onyeka IP, Bako SP, Suleiman MM, Onyegbule FA, Morikwe UC, Ogbue CO.** 2020. Antiulcer effects of methanol extract of *Euphorbia hirta* and honey combination in rats. BioMed Research International **2020**, 6827504. https://doi.org/10.1155/2020/6827504

**Pan SY, Litscher G, Gao SH, Zhou SF, Yu Z, Chen HQ, Zhang SF, Tang MK, Sun JN, Ko KM.** n.d. Historical perspective of traditional indigenous medical practices. https://scholars.hkbu.edu.hk/files/55629504/RO_hkbu_staff_publication-1796_JA026109.pdf

**Patel MO, Shirsat M.** 2025. Synthesis, characterization and evaluation of antioxidant activity of novel combined heterocyclic compounds. https://mlcpharmacy.edu.in/copambajogai/resources/assets/upload/file/985_20240502084939.pdf

**Pounikar Y, Jain P, Khurana N, Patil S, Omray LK, Gajbhiye A.** 2013. Medicinal importance of *Euphorbia hirta* Linn. https://www.cabidigitallibrary.org/doi/full/10.5555/20133337404

**Puspitasari M, Abun A, Rochana A, Widjastuti T.** 2022. Potential of young and old *Euphorbia hirta* leaves extract as antibacterial against *Escherichia coli* and antihelminthic against *Ascaridia galli* in Sentul chickens. Biodiversitas Journal of Biological Diversity **23**(6). https://smujo.id/biodiv/article/view/10868

**Quetin-Leclercq J, Hue BTB.** 2018. Protective effect of some extracts and isolated compounds from *Euphorbia hirta* on pancreatic β-cells MIN6. Vietnam Journal of Science and Technology **56**(4), 163–170.

**Rajeh MAB, Kwan YP, Zakaria Z, Latha LY, Jothy SL, Sasidharan S.** 2012. Acute toxicity impacts of *Euphorbia hirta* L. extract on behaviour, organ body-weight index and histopathology in mice and *Artemia salina*. Pharmacognosy Research **4**(3), 170.

**Ramond J-B, Jordaan K, Díez B, Heinzelmann SM, Cowan DA.** 2022. Microbial biogeochemical cycling of nitrogen in arid ecosystems. Microbiology and Molecular Biology Reviews **86**(2), e00109-21. https://doi.org/10.1128/mmbr.00109-21

**Selvam P, Vijayakumar T, Wadhwani A, Muthulakshmi L.** 2019. Bioreduction of silver nanoparticles from aerial parts of *Euphorbia hirta* L. and their potent anticancer activities against neuroblastoma cell lines. Indian Journal of Biochemistry and Biophysics **56**(2), 132–136.

**Shaaban MT, Ghaly MF, Fahmi SM.** 2021. Antibacterial activities of hexadecanoic acid methyl ester and green-synthesized silver nanoparticles against multidrug-resistant bacteria. Journal of Basic Microbiology **61**(6), 557–568. https://doi.org/10.1002/jobm.202100061

**Szczepańska P, Rychlicka M, Groborz S, Kruszyńska A, Ledesma-Amaro R, Rapak A, Gliszczyńska A, Lazar Z.** 2023. Anticancer and antioxidant activities of resveratrol and long-chain fatty acid esters. International Journal of Molecular Sciences **24**(8), 7167.

**Tripathi AN, Sati SC, Kumar P.** 2021. *Euphorbia hirta* Linn., an invasive plant: traditional uses, phytochemistry and pharmacological properties. System **17**, 22.

**Tuhin RH, Begum MM, Rahman MS, Karim R, Begum T, Ahmed SU, Mostofa R, Hossain A, Abdel-Daim M, Begum R.** 2017. Wound healing effect of *Euphorbia hirta* Linn. (Euphorbiaceae) in alloxan-induced diabetic rats. BMC Complementary Medicine and Therapies **17**(1), 423. https://doi.org/10.1186/s12906-017-1930-x

**Upadhyay A, Chattopadhyay P, Goyary D, Mazumder PM, Veer V.** 2014. *Euphorbia hirta* accelerates fibroblast proliferation and Smad-mediated collagen production in rat excision wound. Pharmacognosy Magazine **10**(Suppl. 3), S534.

**Wang L, Pan X, Jiang L, Chu Y, Gao S, Jiang X, Zhang Y, Chen Y, Luo S, Peng C.** 2022. Biological activity mechanisms of chlorogenic acid and applications in the food industry. Frontiers in Nutrition **9**, 943911.

**Widyananda MH, Fatchiyah F, Muflikhah L, Ulfa SM, Widodo N.** 2023. Computational examination reveals kaempferol as the most potent active compound from *Euphorbia hirta* against breast cancer targeting AKT1 and ER. Egyptian Journal of Basic and Applied Sciences **10**(1), 753–767. https://doi.org/10.1080/2314808X.2023.2272385

**Wu J, Zhang X, Guo L, Sheng Z.** 2024. Bioactivity-guided isolation of potential antidiarrheal constituents from *Euphorbia hirta* L. and molecular docking evaluation. Frontiers in Veterinary Science **11**, 1451615.

**Xia M, Liu L, Qiu R, Li M, Huang W, Ren G, Zhang J.** 2018. Anti-inflammatory and anxiolytic activities of *Euphorbia hirta* extract in neonatal asthmatic rats. AMB Express **8**(1), 179. https://doi.org/10.1186/s13568-018-0707-z

**Zhang R, Tang C, Jiang B, Mo X, Wang Z.** 2025. Characterization of volatile compound profiles and identification of key odor-active compounds in 40 sweet potato (*Ipomoea batatas* L.) varieties. Food Chemistry X **25**, 102058.

**Zhang Y, Lu Z, Zhang D, Li J.** 2021. Complete chloroplast genome of *Euphorbia hirta* (Euphorbiaceae), a commonly used medicinal plant in China. Mitochondrial DNA Part B **6**(8), 2166–2168. https://doi.org/10.1080/23802359.2021.1945506