Chapter 4

Phytochemical Constituents and Pharmacological Activities of Bioactive Compounds from Different Parts of Euphorbia hirta Linn

Bharath Giridharan[a], P. Amudha[b], Manjunathan Jagadeesan[a*]

[a]Department of Biotechnology, School of Life Sciences, Vels Institute of Science, Technology & Advanced Studies, Chennai

[b]Department of Biochemistry, School of Life Sciences, Vels Institute of Science, Technology & Advanced Studies, Chennai

** Corresponding Author:* jmanjunathan@gmail.com

Abstract

Medicinal plants have played a crucial role in traditional healthcare systems across the world. Among them, *Euphorbia hirta* Linn a member of the family Euphorbiaceae, has gained significant attention due to its wide range of therapeutic applications. The plant is widely distributed in tropical and subtropical regions and is traditionally used to treat various ailments including asthma, gastrointestinal disorders, skin infections, and inflammatory diseases. Phytochemical investigations have revealed that different parts of *Euphorbia hirta*, such as leaves, stems, roots, flowers, and latex, contain numerous bioactive compounds including flavonoids, alkaloids, tannins, phenolic acids, terpenoids, and glycosides. These phytoconstituents are responsible for various pharmacological activities such as antimicrobial, antioxidant, anti-inflammatory, antidiabetic, antimalarial, and anticancer effects. The present chapter provides a comprehensive overview of the phytochemical composition and pharmacological properties of different parts of *Euphorbia hirta*,

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highlighting its potential as a valuable medicinal plant for the development of novel therapeutic agents.

Keywords: Euphorbia hirta Linn; Secondary metabolites; bioactive compounds; Pharmacological activities; Antioxidant activity;

1. Introduction

Medicinal plants have been used for thousands of years as primary healthcare resources for treating various diseases. According to the World Health Organization (WHO), nearly 80% of the global population relies on traditional plant-based medicines for primary healthcare needs. These plants contain a wide range of bioactive compounds that contribute to their therapeutic effects.

Euphorbia hirta Linn. is one such medicinal plant belonging to the family Euphorbiaceae. It is commonly known as asthma weed, snake weed, or hairy spurge. The plant has been extensively used in traditional medicine systems such as Ayurveda, Traditional Chinese Medicine, and African folk medicine for the treatment of respiratory disorders, gastrointestinal infections, skin diseases, and inflammatory conditions [1].

The pharmacological importance of *Euphorbia hirta* is mainly attributed to the presence of various secondary metabolites including flavonoids, alkaloids, terpenoids, tannins, and phenolic compounds. Scientific investigations have demonstrated that extracts obtained from different parts of the plant exhibit a wide range of biological activities, including antimicrobial, antioxidant, anti-inflammatory, antidiabetic, and anticancer activities.

Due to its rich phytochemical composition and diverse pharmacological properties, *Euphorbia hirta* has attracted considerable interest among researchers and pharmaceutical

scientists. This chapter aims to evaluate the bioactive compounds present in different parts of the plant and summarize their pharmacological activities [2].

2. Taxonomy and Botanical Description

2.1 Taxonomical Classification

Figure 1. Euphorbia hirta plant

Category	**Classification**
Kingdom	Plantae
Division	Angiosperms
Class	Eudicots
Order	Malpighiales
Family	Euphorbiaceae
Genus	*Euphorbia*
Species	*Euphorbia hirta* Linn

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2.2 Botanical Description

Euphorbia hirta is an erect or prostrate annual herb that grows up to 30–60 cm in height. The plant is characterized by its hairy stems, small leaves, and milky latex. The stems are reddish or purplish in color and covered with fine hairs.

The leaves are simple, opposite, and elliptic in shape with serrated margins. They typically measure 1–4 cm in length. The plant produces small yellowish or greenish flowers that occur in clusters known as cyathia. The fruits are small capsules that contain tiny seeds.

One distinctive feature of *Euphorbia hirta* is the presence of milky latex, which is released when the plant is injured. This latex contains various chemical compounds that contribute to its medicinal properties [3].

3. Distribution and Habitat

Euphorbia hirta is widely distributed in tropical and subtropical regions of the world. It is commonly found in Asia, Africa, Australia, and the Americas. The plant grows abundantly in open grasslands, roadside areas, agricultural fields, and waste lands.

In India, the plant is widely distributed in states such as Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, and Maharashtra. It grows well in warm climates and prefers well-drained soils.

Due to its adaptability and rapid growth, *Euphorbia hirta* is often considered a weed in agricultural fields. However, its medicinal value has made it an important plant in ethnomedicine [4].

4. Traditional Uses of *Euphorbia hirta*

Traditional medicine systems have long recognized the therapeutic potential of *Euphorbia hirta*. Different parts of the plant have been used to treat a variety of ailments.

Major traditional uses include:

- Respiratory disorders: The plant is commonly used to treat asthma, bronchitis, and cough.
- Gastrointestinal diseases: It is used as an antidiarrheal agent and for the treatment of dysentery.
- Skin diseases: Latex from the plant is applied to treat wounds, warts, boils, and fungal infections.
- Fever and inflammation: Extracts of the plant are used to reduce fever and inflammation.
- Lactation stimulant: In some traditional systems, the plant is used as a galactagogue to enhance milk production in nursing mothers.
- These traditional uses have inspired scientific research to validate the pharmacological properties of the plant.

5. Phytochemical Constituents of *Euphorbia hirta*

Phytochemical analysis of *Euphorbia hirta* has revealed the presence of a wide range of secondary metabolites. These compounds play an important role in the biological activities of the plant [5].

5.1 Major Classes of Phytochemicals

The major phytochemicals reported in the plant include:

- Flavonoids
- Alkaloids

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- Phenolic compounds
- Tannins
- Terpenoids
- Steroids
- Glycosides
- Saponins
- Coumarins
- Anthraquinones

These compounds exhibit various biological properties such as antioxidant, antimicrobial, and anti-inflammatory activities.

5.2 Important Bioactive Compounds Identified

Several individual compounds have been isolated from *Euphorbia hirta*, including:

- Quercetin
- Kaempferol
- Myricetin
- Rutin
- Gallic acid
- Protocatechuic acid
- β-sitosterol
- α-amyrin
- β-amyrin
- Taraxerol
- Euphorbin A, B, C, D, and E

Flavonoids and phenolic compounds are considered the major contributors to the antioxidant and anti-inflammatory activities of the plant.

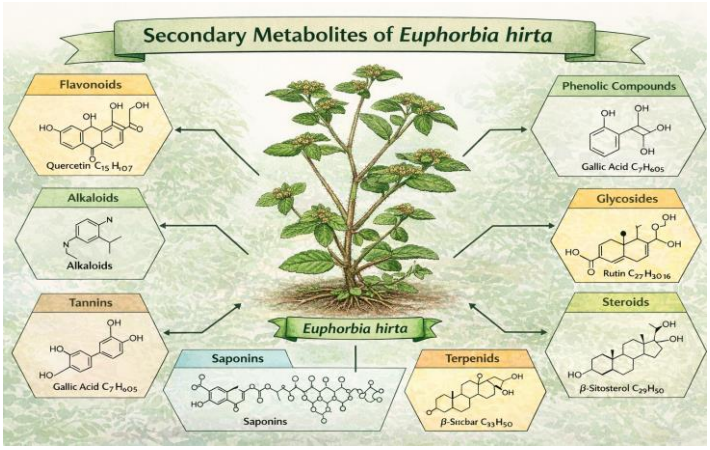

Figure 2. Secondary Metabolites of Euphorbia hirta

Table 1. Major Bioactive Compounds Identified in Different Parts of *Euphorbia hirta*

Plant Part	Major Bioactive Compounds	Chemical Class	Reported Biological Role
Leaves	Quercetin, Kaempferol, Myricetin	Flavonoids	Antioxidant, anti-inflammatory, antimicrobial
Leaves	Gallic acid, Protocatechuic acid	Phenolic acids	Free radical scavenging, antioxidant activity
Leaves	β-Sitosterol	Phytosterol	Anti-inflammatory, cholesterol-lowering effects
Stem	Taraxerol, α-amyrin, β-amyrin	Triterpenoids	Anti-inflammatory and anticancer properties
Stem	Rutin	Flavonoid glycoside	Antioxidant and vascular protective activity
Roots	Alkaloids	Nitrogenous compounds	Antimicrobial and antiparasitic activity
Roots	Tannins	Polyphenols	Astringent and antimicrobial effects
Flowers	Flavonoids and phenolic compounds	Polyphenols	Antioxidant and cytoprotective activity
Latex	Diterpenes and resins	Terpenoids	Antimicrobial and wound healing properties
Whole plant	Euphorbin A, B, C, D, E	Hydrolysable tannins	Antioxidant and anti-inflammatory activities

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6. Evaluation of Bioactive Compounds in Different Parts of the Plant

6.1 Leaves

Leaves are the most extensively studied part of *Euphorbia hirta*. Phytochemical screening of leaf extracts has shown the presence of flavonoids, tannins, phenolics, and terpenoids. The leaf extracts exhibit strong antioxidant activity due to the presence of polyphenolic compounds. Studies using GC–MS analysis have identified several bioactive molecules such as fatty acids, phenolic derivatives, and sterols [7]. These compounds contribute to the antimicrobial, anti-inflammatory, and antidiabetic properties of the plant.

6.2 Stem and Aerial Parts

The stems and aerial parts contain various flavonoids and phenolic compounds. Extracts from these parts have shown antimicrobial activity against several bacterial and fungal pathogens. In addition, the aerial parts contain triterpenoids and sterols that contribute to anti-inflammatory and antioxidant effects [8].

6.3 Roots

Although less studied compared to leaves, the roots of *Euphorbia hirta* contain several alkaloids and triterpenoids. Root extracts have demonstrated antimicrobial and anti-inflammatory activities in laboratory studies. Traditional medicine practitioners often use root preparations for treating digestive disorders and parasitic infections [9].

6.4 Flowers

The flowers contain flavonoids and phenolic compounds that exhibit antioxidant activity. Although fewer studies have been conducted on

the flowers, they are believed to contribute to the overall medicinal properties of the plant.

6.5 Latex

The latex of *Euphorbia hirta* contains diterpenes, resins, and enzymes. It is traditionally used for treating skin infections, warts, and wounds. However, the latex may cause irritation if applied excessively, and therefore its use should be carefully controlled.

7. Pharmacological Activities of *Euphorbia hirta*

Euphorbia hirta has been extensively studied for its pharmacological potential due to the presence of numerous bioactive phytochemicals such as flavonoids, phenolics, alkaloids, tannins, terpenoids, and steroids. Scientific investigations have demonstrated that different extracts of the plant exhibit a wide range of biological activities. These pharmacological properties support the traditional medicinal uses of the plant in the treatment of several diseases [10].

7.1 Antimicrobial Activity

The antimicrobial activity of *Euphorbia hirta* has been widely studied against various pathogenic microorganisms. Extracts from the leaves, stems, and roots have demonstrated inhibitory effects against both Gram-positive and Gram-negative bacteria as well as certain fungal species.

7.1.1 Antibacterial Activity

Several studies have shown that plant extracts exhibit significant antibacterial activity against common pathogenic bacteria.

Common bacteria affected include:

- *Escherichia coli*

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- *Staphylococcus aureus*
- *Pseudomonas aeruginosa*
- *Bacillus subtilis*

The antibacterial activity is mainly attributed to flavonoids, tannins, and phenolic compounds present in the plant [12].

7.1.2 Antifungal Activity

Extracts of *Euphorbia hirta* have also demonstrated antifungal properties against fungi such as:

- *Candida albicans*
- *Aspergillus niger*
- *Trichophyton* species

The antifungal activity is believed to occur through disruption of fungal cell membranes and inhibition of fungal enzyme systems.

7.1.3 Mechanism of Antimicrobial Action

The antimicrobial effect of the plant may occur through several mechanisms:

- Disruption of microbial cell membranes
- Inhibition of nucleic acid synthesis
- Interference with protein synthesis
- Inactivation of microbial enzymes

7.2 Antioxidant Activity

Oxidative stress plays an important role in the development of many chronic diseases such as cancer, diabetes, cardiovascular diseases, and neurodegenerative disorders. *Euphorbia hirta* contains several antioxidant compounds that help neutralize free radicals [14].

7.2.1 Free Radical Scavenging Activity

The plant exhibits strong free radical scavenging activity in assays such as:

- DPPH assay
- ABTS assay
- Hydrogen peroxide scavenging assay
- Nitric oxide scavenging assay

Flavonoids and phenolic acids present in the plant are mainly responsible for this activity.

7.2.2 Role of Phenolic Compounds

Phenolic compounds such as gallic acid and protocatechuic acid contribute significantly to the antioxidant activity by donating hydrogen atoms to neutralize free radicals [15].

7.2.3 Protective Effects against Oxidative Stress

Oxidative stress occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms. Excessive ROS can damage cellular components such as lipids, proteins, and nucleic acids, leading to the development of various chronic diseases including cancer, cardiovascular disorders, diabetes, and neurodegenerative diseases. Antioxidants present in *Euphorbia hirta* play an important role in protecting biological systems from oxidative damage. The plant contains several phenolic compounds and flavonoids that exhibit strong free radical scavenging activity. These compounds help neutralize harmful reactive oxygen species and prevent lipid peroxidation, a process that damages cell membranes and disrupts cellular function. In addition, the antioxidant compounds found in

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Euphorbia hirta may protect cellular membranes from oxidative deterioration and reduce oxidative damage to important biomolecules such as DNA and proteins. By maintaining cellular integrity and preventing oxidative stress, the plant contributes to the protection of tissues and organs from degenerative damage.

7.3 Anti-Inflammatory Activity

Inflammation is a complex biological response that occurs in the body as a defense mechanism against infection, injury, or harmful stimuli. It involves a series of physiological processes designed to eliminate pathogens, remove damaged tissues, and initiate healing. However, prolonged or excessive inflammation can contribute to the development of several chronic diseases, including arthritis, cardiovascular disorders, diabetes, and certain cancers. Medicinal plants with anti-inflammatory properties are therefore of great interest in pharmaceutical research. *Euphorbia hirta* has been reported to possess significant anti-inflammatory activity due to the presence of various bioactive compounds such as flavonoids, terpenoids, and phenolic substances. Extracts from different parts of the plant have shown the ability to reduce inflammation by interfering with inflammatory pathways and suppressing the release of inflammatory mediators [16].

7.3.1 Inhibition of Inflammatory Mediators

One of the primary mechanisms responsible for the anti-inflammatory effects of *Euphorbia hirta* is the inhibition of inflammatory mediators. During the inflammatory response, several chemical mediators such as prostaglandins, histamines, cytokines, and nitric oxide are released at the site of tissue injury or infection. These mediators play important roles in promoting vasodilation,

increasing vascular permeability, and attracting immune cells to the affected area. However, excessive production of these mediators can lead to chronic inflammation and tissue damage. Studies have indicated that extracts of *Euphorbia hirta* can suppress the production and activity of these inflammatory substances. By reducing the synthesis of prostaglandins and inhibiting the release of histamines and cytokines, the plant helps control inflammatory reactions and minimize tissue damage [18].

7.3.2 Experimental Evidence

Several experimental studies have been conducted to evaluate the anti-inflammatory activity of *Euphorbia hirta*. Animal models are commonly used to assess the effectiveness of plant extracts in reducing inflammation. In particular, studies using carrageenan-induced paw edema in laboratory animals have demonstrated significant reduction in swelling following treatment with plant extracts. This model is widely used to evaluate anti-inflammatory agents because carrageenan triggers an acute inflammatory response similar to that observed in human inflammation. Similarly, formalin-induced inflammation models have also shown that *Euphorbia hirta* extracts can reduce pain and inflammation in affected tissues. These experimental findings provide scientific evidence supporting the traditional use of the plant for treating inflammatory conditions [19].

7.3.3 Role of Flavonoids and Terpenoids

The anti-inflammatory activity of *Euphorbia hirta* is largely attributed to the presence of flavonoids and terpenoids. Flavonoids are well known for their ability to inhibit enzymes involved in the inflammatory process, such as cyclooxygenase (COX) and lipoxygenase (LOX). These enzymes are responsible for the production

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of prostaglandins and leukotrienes, which are key mediators of inflammation. By inhibiting these enzymes, flavonoids reduce the formation of inflammatory substances and help control inflammation. Terpenoids, another group of bioactive compounds found in the plant, also exhibit anti-inflammatory effects by modulating immune responses and suppressing the production of inflammatory cytokines. The combined action of these phytochemicals contributes to the overall anti-inflammatory potential of *Euphorbia hirta* [20].

7.4 Antidiabetic Activity

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels resulting from impaired insulin secretion, insulin resistance, or both. The disease is associated with several complications, including cardiovascular disease, neuropathy, nephropathy, and retinopathy. In recent years, medicinal plants have gained increasing attention as potential sources of natural antidiabetic agents due to their effectiveness and relatively low side effects. *Euphorbia hirta* has shown promising antidiabetic activity in several pharmacological studies. The presence of bioactive compounds such as flavonoids, tannins, and phenolic acids may contribute to its ability to regulate glucose metabolism and improve insulin function [21].

7.4.1 Blood Glucose Reduction

Experimental studies have demonstrated that extracts of *Euphorbia hirta* can significantly reduce blood glucose levels in diabetic animal models. The hypoglycemic effect of the plant may be attributed to its ability to enhance insulin secretion, improve insulin sensitivity, and promote glucose uptake by peripheral tissues. In addition, the

antioxidant properties of the plant may protect pancreatic β-cells from oxidative damage, thereby improving their ability to produce insulin. These combined effects contribute to better regulation of blood glucose levels in diabetic conditions [22].

7.4.2 Enzyme Inhibition

Another important mechanism responsible for the antidiabetic activity of *Euphorbia hirta* is the inhibition of digestive enzymes involved in carbohydrate metabolism. Enzymes such as α-amylase and α-glucosidase play essential roles in the breakdown of complex carbohydrates into simple sugars that are absorbed into the bloodstream. By inhibiting these enzymes, plant extracts can slow down carbohydrate digestion and reduce the rate of glucose absorption in the intestine. As a result, postprandial blood glucose levels are lowered, which helps in the effective management of diabetes mellitus [23].

7.4.3 Decrease in Intestinal Fluid Secretion

In addition to reducing intestinal motility, *Euphorbia hirta* may also help control diarrhea by decreasing excessive fluid secretion in the intestinal tract. During diarrheal conditions, the intestinal mucosa secretes large amounts of electrolytes and water into the lumen, leading to watery stools and dehydration. Certain phytochemicals present in the plant may inhibit secretory processes within the intestinal epithelium, thereby reducing fluid loss. This effect helps maintain electrolyte balance and prevents dehydration associated with severe diarrhea [24].

7.4.4 Antispasmodic Effects

Another important property of *Euphorbia hirta* in the management of gastrointestinal disorders is its antispasmodic activity. Intestinal

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spasms often occur during diarrhea and other digestive disturbances, resulting in abdominal pain and discomfort. Bioactive compounds present in the plant may help relax smooth muscles in the intestinal wall, thereby reducing spasms and relieving abdominal cramps. By relaxing intestinal muscles and stabilizing gastrointestinal motility, *Euphorbia hirta* contributes to the overall improvement of digestive health and provides relief from symptoms associated with gastrointestinal disorders [25].

7.4.5 Improvement of Insulin Sensitivity

In addition to its ability to reduce blood glucose levels, *Euphorbia hirta* has been reported to improve insulin sensitivity in peripheral tissues. Insulin sensitivity refers to the capacity of cells to respond effectively to insulin and absorb glucose from the bloodstream. Reduced insulin sensitivity, often referred to as insulin resistance, is a major contributing factor in the development of type 2 diabetes mellitus. Several phytochemicals present in *Euphorbia hirta*, particularly flavonoids, phenolic compounds, and triterpenoids, are believed to enhance insulin sensitivity through multiple biochemical mechanisms. These compounds may stimulate the activity of glucose transporter proteins such as GLUT-4, which facilitates the uptake of glucose into muscle and adipose tissues. Furthermore, the antioxidant properties of the plant help reduce oxidative stress, a factor known to impair insulin signaling pathways. By protecting pancreatic β-cells and improving cellular glucose uptake, the phytoconstituents of *Euphorbia hirta* may contribute to improved glycemic control and overall metabolic balance. These properties suggest that the plant could serve as a promising natural source for the development of antidiabetic therapeutics [26].

7.5 Antimalarial Activity

Malaria remains one of the most serious infectious diseases affecting millions of people worldwide, particularly in tropical and subtropical regions. The disease is caused by protozoan parasites belonging to the genus *Plasmodium*, which are transmitted to humans through the bite of infected female *Anopheles* mosquitoes. Despite the availability of various antimalarial drugs, the emergence of drug-resistant strains of malaria parasites has become a significant challenge in global health. Consequently, the search for new antimalarial agents from natural sources has gained considerable attention. Medicinal plants have historically played a crucial role in antimalarial drug discovery, with well-known examples such as quinine and artemisinin originating from plant sources. In recent years, *Euphorbia hirta* has been investigated for its potential antimalarial properties due to the presence of several bioactive phytochemicals. Extracts prepared from different parts of the plant have demonstrated inhibitory effects against malaria parasites in laboratory studies, indicating its potential as a valuable source of antimalarial compounds [27].

7.5.1 Inhibition of *Plasmodium falciparum*

Among the various species of malaria parasites, *Plasmodium falciparum* is considered the most dangerous because it is responsible for the majority of severe malaria cases and fatalities worldwide. Several experimental studies have reported that methanolic and ethanolic extracts of *Euphorbia hirta* exhibit inhibitory activity against *Plasmodium falciparum*. In vitro assays have shown that exposure of malaria parasites to plant extracts results in reduced parasite growth and multiplication. The inhibitory effect may be attributed to the ability of plant phytochemicals to interfere with essential metabolic

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processes required for parasite survival. These compounds may disrupt the parasite's enzymatic activities, inhibit nucleic acid synthesis, or impair membrane integrity. As a result, the life cycle of the malaria parasite may be interrupted, thereby reducing its ability to infect and multiply within host cells [28].

7.5.2 Possible Active Compounds

The antimalarial activity of *Euphorbia hirta* is believed to be associated with several bioactive phytochemicals present in the plant. Flavonoids are considered one of the major contributors to this activity due to their ability to inhibit parasite growth by interfering with enzyme systems and nucleic acid synthesis. Alkaloids present in the plant may also contribute to antimalarial effects by disrupting metabolic pathways essential for parasite survival. In addition, phenolic compounds possess strong antioxidant properties that may help reduce oxidative damage associated with malaria infection. Terpenoids and other secondary metabolites found in *Euphorbia hirta* may also play a role by affecting the structural integrity of parasite cell membranes. These compounds may act individually or synergistically, enhancing the overall antimalarial potential of the plant [29].

7.5.3 Potential for Drug Development

The growing resistance of malaria parasites to commonly used antimalarial drugs has created an urgent need for new and effective therapeutic agents. Medicinal plants have long served as valuable sources of bioactive compounds for pharmaceutical development. Due to its diverse phytochemical composition and demonstrated biological activity, *Euphorbia hirta* represents a promising candidate for further research in antimalarial drug discovery. Isolation and

characterization of active compounds from the plant could lead to the identification of novel antimalarial agents with improved efficacy and reduced toxicity. Furthermore, modern analytical techniques such as high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), and molecular docking studies may facilitate the identification of specific compounds responsible for antimalarial activity. Continued research in this area may ultimately contribute to the development of new plant-based antimalarial drugs [30].

7.6 Anticancer Activity

Cancer is a complex and multifactorial disease characterized by uncontrolled cell growth, abnormal cell division, and the ability of malignant cells to invade surrounding tissues and spread to distant organs. Despite significant advancements in cancer treatment, the development of safer and more effective therapeutic agents remains an important area of research. Natural products derived from medicinal plants have played a crucial role in the discovery of many anticancer drugs currently used in clinical practice. In recent years, *Euphorbia hirta* has attracted attention due to its potential anticancer properties. Preliminary pharmacological studies suggest that extracts of the plant contain bioactive compounds capable of inhibiting tumor cell growth and inducing cancer cell death. These effects may be attributed to the presence of flavonoids, triterpenoids, phenolic compounds, and other secondary metabolites that exhibit cytotoxic and antiproliferative activities [31].

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Table 2. Pharmacological Activities of *Euphorbia hirta* and Their Experimental Evidence

Pharmacological Activity	Plant Part Used	Type of Extract	Experimental Model / Target	Major Findings
Antimicrobial	Leaves	Methanol extract	*E. coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*	Significant inhibition of bacterial growth
Antifungal	Whole plant	Ethanol extract	*Candida albicans*, *Aspergillus niger*	Effective antifungal activity observed
Antioxidant	Leaves	Aqueous and methanol extracts	DPPH and ABTS assays	Strong free radical scavenging activity
Anti-inflammatory	Aerial parts	Hexane extract	Carrageenan-induced paw edema in rats	Reduction in inflammation observed
Antidiabetic	Leaves	Ethanol extract	Streptozotocin-induced diabetic rats	Reduction in blood glucose levels
Antimalarial	Whole plant	Methanol extract	*Plasmodium falciparum*	Moderate antimalarial activity reported
Anticancer	Leaves	Methanol extract	Human cancer cell lines	Cytotoxic activity against cancer cells
Antidiarrheal	Leaves	Aqueous extract	Castor oil-induced diarrhea in mice	Decreased intestinal motility and secretion

Table 3. Traditional Uses of Different Parts of *Euphorbia hirta*

Plant Part	Traditional Use	Method of Application
Leaves	Treatment of asthma and cough	Leaf decoction or juice
Leaves	Diarrhea and dysentery	Aqueous extract
Roots	Digestive disorders	Root infusion
Whole plant	Fever and inflammation	Herbal decoction
Latex	Wounds, warts, and skin infections	Topical application
Flowers	Antioxidant and tonic	Herbal preparation

7.6.1 Cytotoxic Effects

Cytotoxic activity refers to the ability of a substance to kill or damage living cells, particularly cancer cells. Several experimental studies have reported that extracts of *Euphorbia hirta* exhibit cytotoxic effects against different human cancer cell lines. Laboratory investigations have demonstrated inhibitory activity against breast cancer cells, liver cancer cells, lung cancer cells, and colon cancer cells. The cytotoxic effect may result from the interaction of phytochemicals with cellular components involved in cell survival and proliferation. These compounds may interfere with mitochondrial function, disrupt cellular metabolism, or damage DNA, ultimately leading to cancer cell death. Such findings highlight the potential of *Euphorbia hirta* as a promising source of natural anticancer compounds [32].

7.6.2 Induction of Apoptosis

Apoptosis, also known as programmed cell death, is a natural process by which the body eliminates damaged or abnormal cells. Many anticancer therapies aim to induce apoptosis in tumor cells as a means of preventing cancer progression. Bioactive compounds present in *Euphorbia hirta* may trigger apoptosis through various

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molecular mechanisms. These include activation of apoptotic signaling pathways, disruption of mitochondrial membrane potential, release of cytochrome-c, and activation of caspase enzymes responsible for initiating the apoptotic process. By inducing apoptosis, the phytochemicals present in the plant help eliminate cancerous cells while minimizing damage to surrounding healthy tissues [33].

7.6.3 Antiproliferative Activity

In addition to inducing apoptosis, compounds present in *Euphorbia hirta* may inhibit the proliferation of cancer cells. Antiproliferative activity refers to the ability of a substance to prevent the rapid multiplication of abnormal cells. Flavonoids and triterpenoids found in the plant may interfere with cell cycle regulation, thereby preventing cancer cells from progressing through different stages of the cell division cycle. Furthermore, these compounds may inhibit angiogenesis, the process by which new blood vessels form to supply nutrients and oxygen to growing tumors. By suppressing cell proliferation and reducing tumor blood supply, the phytochemicals of *Euphorbia hirta* may contribute to the control of tumor growth and progression [34].

7.7 Antidiarrheal and Gastroprotective Activity

Euphorbia hirta has been widely used in traditional medicine systems for the treatment of gastrointestinal disorders, particularly diarrhea and dysentery. Diarrhea is characterized by frequent and watery bowel movements, often accompanied by abdominal pain and dehydration. The plant's effectiveness in treating diarrhea has been supported by several pharmacological studies. Extracts of *Euphorbia hirta* are believed to exert their antidiarrheal effects through multiple

mechanisms that regulate intestinal motility, fluid secretion, and mucosal protection. These properties make the plant a valuable natural remedy for managing digestive disorders [35].

7.7.1 Reduction of Intestinal Motility

One of the key mechanisms responsible for the antidiarrheal activity of *Euphorbia hirta* is the reduction of intestinal motility. Excessive movement of intestinal muscles can result in rapid transit of intestinal contents, preventing proper absorption of water and electrolytes. Experimental studies have demonstrated that plant extracts can slow down intestinal contractions, thereby allowing sufficient time for fluid absorption in the gastrointestinal tract. This reduction in intestinal motility helps decrease the frequency of bowel movements and improves stool consistency. Consequently, the plant extract plays an important role in alleviating symptoms associated with diarrhea.

8. Conclusion

Euphorbia hirta Linn. is an important medicinal plant that has gained considerable attention due to its diverse pharmacological properties and rich phytochemical composition. Various parts of the plant, including the leaves, stems, roots, flowers, and latex, contain numerous bioactive compounds such as flavonoids, phenolic acids, tannins, alkaloids, terpenoids, and sterols. These phytochemicals are responsible for a wide range of biological activities that support the traditional medicinal uses of the plant in many parts of the world.

Scientific investigations have confirmed that extracts of *Euphorbia hirta* exhibit significant pharmacological activities, including antioxidant, antimicrobial, anti-inflammatory, antidiabetic, antimalarial, anticancer, and antidiarrheal effects. The antioxidant

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properties of the plant help protect biological systems from oxidative stress and cellular damage, while its anti-inflammatory activity contributes to the regulation of inflammatory responses. Furthermore, the plant has shown promising potential in the management of metabolic disorders such as diabetes by reducing blood glucose levels and improving insulin sensitivity. Its antimicrobial and antimalarial properties also highlight its potential role in combating infectious diseases.

In addition, recent studies have explored the anticancer potential of *Euphorbia hirta*, indicating that certain bioactive compounds present in the plant may induce apoptosis and inhibit the proliferation of cancer cells. The plant has also demonstrated beneficial effects in the treatment of gastrointestinal disorders, particularly diarrhea, by reducing intestinal motility, decreasing fluid secretion, and exerting antispasmodic effects. These findings collectively suggest that *Euphorbia hirta* is a valuable source of natural therapeutic agents.

Despite these promising pharmacological activities, further research is necessary to fully understand the mechanisms of action, toxicity profiles, and clinical efficacy of the plant's bioactive compounds. Advanced analytical techniques and well-designed clinical studies are required to isolate and characterize the active constituents and evaluate their potential for drug development. Overall, *Euphorbia hirta* represents a promising medicinal plant with significant potential for the development of novel pharmaceutical and therapeutic applications in modern medicine.

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