

Review on a potential multipurpose plant: *Euphorbia tirucalli* L.¹Maroti Parmeshwar Sonarkhan*, ²Prashant J. Wagh and ³Mrunal C. Kale¹Research Scholar, Anand Niketan College, Anandwan Warora, Chandrapur, Maharashtra, India (Gondwana University Gadchiroli, Maharashtra, India)²Assistant Professor, Anand Niketan College, Anandwan Warora, Chandrapur, Maharashtra, India (Gondwana University Gadchiroli, Maharashtra, India)³Principal, Anand Niketan College, Anandwan Warora, Chandrapur, Maharashtra, India (Gondwana University Gadchiroli, Maharashtra, India)¹marotisonarkhan01@gmail.com, ²waghprashant2408@gmail.com and ³mrunkale24@gmail.com

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Received: 14th June, 2026; Revised: 20th July 2026; Accepted: 20th August, 2026; Available Online: 05th September 2026**ABSTRACT**

Euphorbia tirucalli L. (*Euphorbiaceae*), also referred to as the milk bush or pencil tree, is a drought-tolerant succulent species known for its exceptional potential for use in medicine, industry, and renewable energy. Originally from tropical Africa and now widely distributed throughout Asia and the Americas, the plant has long been used in traditional medicine to treat rheumatism, skin conditions, inflammation, respiratory conditions, and various infectious diseases. In recent years, growing interest in sustainable bioresources has highlighted *E. tirucalli* as a promising multipurpose crop because of its hydrocarbon-rich latex, high biomass productivity, and ability to thrive on marginal lands under arid conditions. This review critically summarizes the current knowledge on the taxonomy, geographical distribution, morphology, cultivation practices, phytochemical composition, ethnomedicinal applications, pharmacological activities, toxicity, and biofuel potential of *E. tirucalli*. Evidence from published studies demonstrates that the plant is rich in terpenoids, triterpenoids, flavonoids, phenolic compounds, and other bioactive constituents responsible for its anti-inflammatory, anticancer properties, antimicrobial, antiviral, and antioxidant. Furthermore, its latex and biomass have shown considerable potential for biodiesel, biogas, and other renewable energy applications, supporting its role in sustainable energy production. Future research should focus on detailed mechanistic studies, toxicity evaluation, clinical investigations, standardization of bioactive compounds, and optimization of large-scale cultivation and biofuel production. Overall, *Euphorbia tirucalli* represents a valuable multipurpose plant with significant potential for pharmaceutical, agricultural, industrial, and renewable energy applications.

Keywords: *Euphorbia tirucalli*, L. Multipurpose plant, Phytochemistry, Pharmacological activities, Toxicity, Traditional Medicinal.

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1. INTRODUCTION

Euphorbia tirucalli L., a rare blooming shrub or small tree in the '*Euphorbiaceae*' family, is distinguished by its thin, green, cylindrical twigs that resemble pencils [1]. Its popular name, pencil tree, is derived from its woody, succulent, leafless branches; it is also known as Indian tree spurge and miracle plant. Although it is now widely naturalised in many regions of India, particularly in the dry and semi-arid dry zones, such as South India and Bengal, it is originally found in tropical and subtropical Africa and America [2]. It is a xerophyte and is often grown as hedge plant in farmlands and gardens as an ornamental plant. Its scientific classification is within the domain 'Eukaryota and kingdom Plantae, order Malpighiales and genus '*Euphorbia*',' which is typical of other medicinally important species belonging to the *Euphorbiaceae* family [3]. Numerous colloquial names for *E. tirucalli* L. exist around the world, demonstrating its widespread usage and popularity.

The plant is commonly known as the pencil tree, milk bush, and fire stick plant in regions because of its pencil-like succulent branches, copious milky latex exudate, and reddish coloration that develops under certain environmental conditions. In parts of India, it is referred to as Sher or Sehund, with Barki-Sehund being a Hindi and Urdu name used to distinguish it from other *Euphorbia* species. The plant is well known as Aveloz in Brazil and other Portuguese-speaking nations, where it has a long history of traditional medical usage. The name naked lady is another English vernacular name derived from its distinctive leafless appearance. These diverse local names reflect the plant's broad geographical distribution and its cultural, ethnomedicinal, and traditional significance across different regions of the world [4]. This plant is great impact on Ethnomedical value, the plant produces a milky latex that has been noted for its medicinal properties as well as toxicity requiring special precautions [5].

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E. tirucalli L. value as a versatile medicinal plant and role in industrial plant has expanded in future. Traditional medicine has documented using different parts of the plant, especially the latex, to cure a variety of skin conditions, rheumatism, warts, asthma, cough, colic, jaundice, arthritis, and even some types of cancer [6]. Some active compounds found in plant such as diterpenes, triterpenes, sterol euphol, and phenolic compounds its high medicinal value used for drug discovery. Apart from its therapeutic uses, *E. tirucalli* L. has become a valuable plant for industrial purposes as a source of biofuel due its latex containing hydrocarbons. It has also investigated for use in the production of rubber, resins, and biogas [7].

The plant is cultivated through vegetative propagation by stem cuttings, and sometimes it is propagated by seeds. Cuttings from the central and apical sections may show a 100% survival rate. It utilises healthy stem cuttings from a healthy plant and grows in any kind of soil. Multiplying plants using stem cuttings is the most common method of *Euphorbia tirucalli* L. [8]. Despite its advantages, the plant does have some drawbacks, mainly due to the irritant and toxic nature of its latex, which can induce skin irritation and eye irritation. Thus although it has immense medicinal and industrial potential, these applications need to be carefully handled [9].

The aim of this review is to critically evaluate the current knowledge on *Euphorbia tirucalli* L., including its taxonomy, morphology, ecology, cultivation practices, phytochemical composition, pharmacological properties, industrial applications, and biofuel potential. The growing depletion of conventional natural resources and increasing global energy demands have intensified the search for sustainable and renewable alternatives. In 2025, renewable energy sources accounted for approximately 49.4% of the world's installed electricity-generating capacity, reflecting a rapid global transition toward

cleaner and more sustainable energy systems. As a drought-tolerant species capable of thriving on marginal and arid lands, *E. tirucalli* has attracted considerable attention because of its rich phytochemical profile, diverse medicinal properties, and potential as a source of biofuel feedstock. The species is a prospective contender for both medicinal and industrial uses since studies have shown that it can be grown in challenging environmental circumstances and has considerable potential for producing hydrocarbons and biogas. Thus, the objective of this study is to give a thorough assessment of the biological, medical, and economic relevance of *E. tirucalli* and to emphasise its potential as a sustainable multifunctional plant resource in the future.

2. TAXONOMY AND CLASSIFICATION

The botanical name is a vital part of plant identification across different cultures and languages [10].

2.1. Etymology

The genus name *Euphorbia* is derived from Euphorbus, a Greek physician in the court of King Juba II of Mauretania, in recognition of his contributions to medicinal plant knowledge. The species name *tirucalli* is thought to originate from an East African vernacular name for the plant. The abbreviation L. indicates Carl Linnaeus, who first described and classified the species in *Species Plantarum* in 1753.

“The accepted scientific name of the plant is *Euphorbia tirucalli* L. The plant has been known by several vernacular names and synonyms due to changes in classification and its wide geographical distribution. Proper taxonomy and nomenclature are crucial for maintaining standardization in pharmacological, ecological, and industrial studies involving this species. They also help prevent confusion arising from the use of different local names, which may vary considerably across regions [11].

Table 1: Taxonomic Classification of *Euphorbia tirucalli*

Rank	Classification
Kingdom	Plantae
Sub-kingdom	Tracheobionta
Division	Magnoliophyta
Super-division	Spermatophyta
Class	Magnoliopsida
Sub-class	Rosidae
Order	Malpighiales
Family	Euphorbiaceae
Genus	<i>Euphorbia</i>
Species	<i>Euphorbia tirucalli</i> L.

This taxonomic classification, based on the traditional **Cronquist system of plant classification** with subsequent recognition of the order *Malpighiales* according to modern angiosperm taxonomy, provides a systematic framework for understanding the biological identity of *Euphorbia tirucalli* and its phylogenetic relationship with other members of the family Euphorbiaceae. Such classification is essential for accurate botanical identification, comparative studies, and

the exploration of the plant's pharmacological and ethnomedicinal significance and plant characteristics [12].

3. GEOGRAPHICAL DISTRIBUTION AND HABITAT

Euphorbia tirucalli L. is known and acclaimed for being highly adaptable and widely distributed throughout the world. The plant has been identified as being indigenous to Africa and East in particular. It is thought that the plant originally came from the tropical parts of Africa before

spreading to other continents. Some of the places where the plant can currently be found include Angola, Ethiopia, Kenya, Tanzania, Uganda, Sudan, and Senegal. It is also found in the America and Asia. Some other countries where the plant can be found include Brazil, Indonesia, Malaysia, Vietnam, and the Philippines. As such, this plant has emerged to be one of the widest distributed plants in the genus *Euphorbia* [13]. In India, *E. tirucalli* L. has been able to adapt well and can be found in different parts of country, especially those that are dry or semi-arid. This plant is frequently planted as a hedge around gardens and farms in the drier regions of Bengal and South India [14]

4. MORPHOLOGICAL CHARACTERISTICS

4.1. Whole Plant

Euphorbia tirucalli L. is a small tree or blossoming shrub with straight branches that can reach a height of 4–12 meters and a stem diameter of 15–20 centimetres. It produces smooth, cylindrical, terete, polished, whorled branches during the rainy season [15].

4.2. Leaves

The tiny, linear, speckled leaves are oblanceolate, elongated, and measure between 1.3 and 2.5 cm in length and 2 cm in width. They are exclusively located at the ends of embryonic branches that rapidly decompose. Twisted brown trichomes gently envelop the apices of juvenile, verdant branchlets [16].

4.3. Branches

The elongated, succulent branches are about 7 mm wide and grow perennially. They frequently take the shape of a spiral. An arrangement of three or more limbs that droop, twist, or spiral outward from a central point [17]. Newer branches often lack leaves, are succulent, have a lot of latex, are smooth and fragile, cylindrical, and around 5 to 8 mm in diameter; they look like pencils, fingers, or breadsticks.

4.4. Stem

A milky fluid is released when a new stem breaks. Their green cylindrical size varies from half a centimetre to two centimetres. The main stem and branches of this woody, multi-trunked tree feature a reddish hue.

4.5. Flowers

Clustered at the ends of little branches and on terminal twigs are the small, beautiful bottle-green blossoms. On top of every branchlet are two or six cymes that are too crowded. A thick cluster of cyathia with progressively just single blooms arises when the forking happens twice or four times with heat in less than one minute. It is common for plants to produce male flowers. Bracteoles and, very rarely, a few male flowers make up a female involucre. The three-lobed perianth, which lies underneath the tomentose ovary, has lobes that are half a millimetre long. The 2 mm long styles are tightly bifurcated at the tip, and they adhere to the support [18]. October is the flowering month for the *Euphorbia tirucalli* L., while November and December are the fruiting months. Pollination is done by insects.

4.6. Fruits

The fruit is a glabrescent capsule that is 1 cm long, ruby crimson, and falls from a tomentose pedicel. Their tripartite capsule is spherical and 8–12mm wide. Capsules are dehiscing even while remaining on the tree [19].

4.7. Seeds

The seeds are oval in form and measure around 3.0–4.0, 2.8–3.0 mm. They have a dark coffee-colored border around the little, light cruncle and are sensitive, glabrous, buff, and brown-spotted [20].

4.8. Latex

Sap's strong adhesive capabilities are used to bond spear heads to shafts and knife blades to timber handles all along the East African coast. Latex, a milky white sap that is toxic [21]

4.9. Roots

Lateral roots are produced by the plant to prevent overly profound growth [22].

4.10. Wood

The wood is rather stiff, white, and has fine grains [23]

5. PHYTOCHEMISTRY

Euphorbia tirucalli L. has several economic and medicinal applications, which are backed by its complex and diverse phytochemical profile. In addition to steroids, alkaloids, and tannins, the plant has a high concentration of bioactive chemicals from major classes such as terpenoids, phenolics, and flavonoids. These phytochemicals are responsible for the plant's pharmacological properties as well as therapeutic potential [24].

5.1. Major Bioactive Compounds

Terpenoids

E. tirucalli is mostly composed of terpenoids. Euphol and tirucallol are the principal triterpenoids that have been extensively researched. These compounds have strong biological activity, including anti-inflammatory, anticancer, antiviral, and antibacterial effects. Additional related terpenoids, such as taraxasterol, cycloeuphornol, and alpha-euphorbol, are identified and strengthen the plant's pharmacological profile [25].

Phenolic Compounds

Phenolic chemicals are abundant in plants and known for their powerful antioxidant properties. The phenolic compounds found in *Euphorbia tirucalli* include fulvic acid, gallic acid, caffeic acid, chlorogenic acid, p-coumaric acid, quercetin, vanillic acid, methyl gallate, and derivatives of ellagic acid. A number of other compounds have also been extracted from this plant. The antioxidant capacity of the plant is enhanced by these compounds, which protect cells from oxidative stress and its associated diseases, including as cancer, heart disease, and neurological disorders, by neutralising free radicals. Phenolic chemicals include anti-inflammatory and antibacterial properties, which increase the plant's medicinal potential [26].

Flavonoids

Flavonoids are significant secondary metabolites found in plant aerial parts and are classified as phenolic chemicals. Quercetin, kaempferol, rutin, myricetin, luteolin, and their glycosidic derivatives are among the several flavonoids found in *Euphorbia tirucalli*. These bioactive components are well-known for their potent immunomodulatory, anti-inflammatory, and antioxidant properties. By scavenging reactive oxygen species and reducing lipid peroxidation, flavonoids shield cells from oxidative damage. They also contribute to wound healing, antimicrobial activity, and the prevention of various chronic diseases, thereby enhancing the therapeutic potential of *E. tirucalli* [27].

5.2. Chemical Constituents in Latex Stem and Leaves

Latex

Milky latex is a rich source of bioactive compounds, such as terpenoids and resin materials. It includes euphol, tirucallol, and other diterpenes, as well as sterols and hydrocarbons. The latex also has a resin component of industrial value [28].

Stem

The stem has a high concentration of terpenoids, sterols, and long-chain alcohols, including n-hexacosanol. It also comprises laticiferous canals that sequester latex and enhance the plant's defensive strategies [29].

Leaves

Despite being diminished and ephemeral, they encompass flavonoids, phenolic compounds, and trace quantities of alkaloids and tannins, which enhance antioxidant and antibacterial properties [30].

The entire plant has organic acids, including citric, succinic, and malonic acids, which may contribute to metabolic and medicinal activities.

5.3. Importance of Phytochemicals in Medicinal Activity

The phytochemicals in *Euphorbia tirucalli* L. are directly accountable for its various therapeutic qualities. Terpenoids such as euphol and tirucallol have potential anticancer and anti-inflammatory properties through the modulation of cellular signalling pathways. Phenolic chemicals and flavonoids confirm antioxidant defence, oxidative stress and averting cellular damage [31]. Alkaloids and tannins enhance antibacterial and wound-healing capabilities. The combined effects of these phytochemicals support the traditional application of *E. tirucalli* L. in addressing numerous diseases and underscore its potential as a significant source of bioactive compounds for pharmacological and therapeutic uses.[32]

Table 2: Chemical Constituents Present in Different Parts of *Euphorbia tirucalli*

Plant Part	Phytoconstituents	References
Latex	Triterpenes	[33]
Latex	Diterpene esters of phorbol, 12-deoxyphorbol esters, ingenol	
Latex	β -sitosterol, euphorbol hexacosonate, 12-deoxy-4 β -hydroxyphorbol-13-phenyl acetate-20-acetate, 12,20-dideoxyphorbol-13-isobutyrate, glut-5-en-3 β -ol, euphol	
Latex	4-deoxyphorbol di-ester	
Latex	Cycloeuphordenol (triterpene)	
Latex	Cyclotirucanenol (triterpene)	
Latex	Diterpene ester	
Latex	Highly irritant euphorbia factors (non-specific)	
Latex	Serine proteases	
Latex	Euphol	
Latex	Steroids	
Latex	Tirucallicine (diterpene)	
Latex	Tri-methyl ellagic acid	
Fresh Latex	Terpenic alcohol, isoeuphorol, taraxasterol, tirucallol	
Undried Latex	3,7,12-tri-O-acetyl-8-isovaleryl-ingol	[34]
Dried Latex	Ketone euphorone, resin	
Stem	Hentriacontene, 4-deoxyphorbol ester, hentriacontanol, β -sitosterol, cyclotirucanenol, cycloeuphordenol, corilagin, casuarin, euphorbins, euphorone, euphorcinol, euphol, gallic acid, ellagic acid, glucosides	[35]
Stem	Ellagic acid, taraxerol, 3,3'-di-O-methylellagic acid, β -sitosterol	
Stem	<i>Euphorbin A</i> (polyphenol), <i>Euphorbin F</i> (dimers), <i>Tirucallin A</i> (tannin), <i>Tirucallin B</i>	
Bark	Euphorbol, β -sitosterol, cycloartenol, 24-methylenecycloartenol, ingenol triacetate, euphorbol hexacosonate, 12-deoxy-4 β -hydroxyphorbol-13-phenyl acetate-20-acetate, taraxerone	[36]
Stem-bark	Cycloart-23-ene-3 β ,25-diol, euphorcinol	[37]
Stem-bark	Taraxerane (triterpene)	
Stem-bark	Euphorginol	
Stem-bark	Taraxerol	

Fresh Stem-bark	Euphoriginol, taraxer-14-en-6 α -ol	[38]
Stem Callus	Campesterol, stigmasterol, β -sitosterol, isofucosterol, cycloartenol (sterols), euphol, β -amyirin (triterpenoids)	[39]
Shoot Callus	Sitosterol, stigmasterol, campesterol, palmitic acid, linoleic acid	[40]
Leaves	β -amyirin	[41]

6. TRADITIONAL AND ETHNOMEDICINAL USES

Traditional and ethnomedicinal system have utilised *Euphorbia tirucalli* L for ages across numerous public health. The presence of several bioactive chemicals, especially in its milky latex and aerial sections, is believed to be the reason for its widespread usage in traditional medicine [42]. Traditional medical properties in country like South, America, India, and Africa use the plant, despite its recognised irritating characteristics, provided it is applied carefully and in regulated manner [43]. *Euphorbia tirucalli* L. has a history of use in traditional medicine for the treatment of asthma and persistent cough by using plant-based medicine such as diluted latex or a decoction of the stems. [44]. The plant's anti-fungal and anti-scabies properties have also made it useful in the treatment of eczema and other skin conditions. The caustic effect of the latex, when applied topically in a regulated way, aids in the removal of warts, corns, and other abnormal growths on the skin [45]. Traditional medicine practitioners have long relied on this herb to treat toothaches and gum diseases. Because latex is analgesic and antibacterial, some dentists recommend applying a tiny bit to the painful tooth directly. Due to the latex's irritating and potentially poisonous properties, however, such usage necessitates prudence.

The plant's extracts or latex are used topically to alleviate joint pain and inflammation in rheumatism situations [46]. One theory is that the latex's warming and irritating characteristics may increase blood circulation to the region, alleviating the symptoms [47]. Infections, parasite disorders, and even certain tumours can be alleviated with the use of *E. tirucalli*, according to traditional African medicine [48]. Some traditional practices also include its usage as a purgative and in the treatment of STDs [49]. For illnesses relating to the skin, the abdomen, and enlarged spleen, among others, the plant has a prominent role in Ayurvedic and traditional medicine in India. Because it is often grown as a hedge plant, it is readily available for therapeutic purposes in the nearby area [50]. The plant is utilised in traditional medicine for cancer, ulcers, and respiratory disorders in South American nations like Brazil [51].

The latex and plant extracts of *E. tirucalli* L. are the main components used in traditional medicine. When used topically, the plant's most powerful component, latex, alleviates pain in the joints, skin infections, and warts. Despite widespread disapproval owing to its toxicity, it is but used in extremely small, diluted amounts in certain home treatments. Depending on the condition being treated, decoctions, infusions, or poultices made from extracts of the stem and other aerial parts are used [52].

Although *E. tirucalli* has therapeutic potential as evidenced by its ethnomedicinal applications, it is crucial to be aware that the plant can cause skin irritation, inflammation, and toxicity if used incorrectly. Consequently, predictable understanding stresses the need of careful administration and dose. Taken collected, the many cultural situation in which this plant utilised highlighted its importance as a medicinal resource and lay the groundwork for additional pharmacological studies [53].

7. PHARMACOLOGICAL ACTIVITIES

7.1. Antibacterial/ Antifungal/ Antimicrobial Activity

The agar well diffusion experiment utilised *Bacillus subtilis* (*B. subtilis*), *Klebsiella pneumoniae* (*K. pneumoniae*), *Staphylococcus aureus* (*S. aureus*), and *Pseudomonas aeruginosa* (*P. aeruginosa*) to test the antimicrobial properties of petroleum ether and dichloromethane-methanol extract of *E. tirucalli* latex. Moreover, the agar well diffusion assay was used to evaluate the watery extract against *A. niger*, *Penicillium chrysogenum*, *Trichoderma viride*, and *Candida albicans*. At 5%, 10%, 15%, and 20% concentrations, bacteria showed a zone of decline, whereas fungus showed a zone of decline at 3%, 6%, 9%, and 12%. There was no impact of the test extracts on *B. subtilis* [54].

Using agar diffusion and agar tube dilution assays, the antibacterial and antifungal characteristics of various substances were evaluated. These substances included methanol, chloroform, n-hexane, and water-based extracts from plants such as *Sapindus emarginatus*, *Hibiscus rosa-sinensis*, *Mirabilis jalapa*, *E. tirucalli*, *Vitex negundo*, and *Saussurea lappa* [55]. Studies have shown that an n-hexane extract of *E. tirucalli* at a concentration of 100 mg/mL can reduce the area in question. Testing the antimicrobial potential of various extracts from the stem of *E. tirucalli* was conducted using *Bacillus megaterium*, *B. subtilis*, *E. coli*, *Enterococcus faecalis*, *P. vulgaris*, *S. aureus*, *A. niger*, *Aspergillus fumigatus*, and *Candida albicans*. The solvents used were acetone, chloroform, hexane, petroleum ether, and methanol. One study found that acetone extract inhibited the growth of every single microbe [56]. Acetone extract was shown to be highly effective against *E. coli*. Some reports indicate that chloroform extract does not effectively combat *Candida albicans*, *B. subtilis*, *E. coli*, *P. vulgaris*, *S. aureus*, and *A. niger*. They say that *Candida albicans*, *Bacillus subtilis*, *Escherichia coli*, *Enterococcus faecalis*, and *Staphylococcus aureus* are immune to the methanol extract. Extraction with petroleum ether or hexane showed no impact [57].

Evidence from disc diffusion studies suggests that an alcoholic crude extract of *E. tirucalli* leaves and stems

may have antimicrobial activity against a range of bacteria and fungi, including *Escherichia coli*, *Paracoccus faecalis*, *Salmonella enteritidis*, *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Aspergillus niger*, *Aspergillus fumigatus*, *Aspergillus flavus*, and *Fusarium oxysporum*. Some bacteria, including *S. aureus*, *P. aeruginosa*, *K. pneumoniae*, and *E. coli*, were effectively neutralised by the leaf extract. Stem extract is highly effective against *Klebsiella pneumoniae* and *Proteus mirabilis* [58].

Findings demonstrated that concentration had no bearing on the antifungal action. In contrast to *Candida glabrata*, which was resistant, *A. flavus* was mostly an inclined fungal strain. Using disc diffusion, we tested methanolic, acetone, ethyl acetate, water, and extracts of *Rizoctonia solani*, *A. niger*, *B. subtilis*, *S. aureus*, *E. coli*, and *Pasteurella multocida* against bacterial strains *B. subtilis*, *E. tirucalli*, *E. coli*, and *B. subtilis*. The highest effective concentration of the methanolic extract of *E. tirucalli* against *S. aureus* and *B. subtilis* was found to be 1000 mg. Gemmomodified *E. tirucalli* extract outperformed *E. coli*. [59, 60].

7.2. Anti-inflammatory Activity

At 30 and 100 mg/kg, Euphol was tested for its anti-inflammatory properties by inducing mechanical hyperalgesia with carrageenan. We considered chemokines released by keratinocytes, IL-1 β , IL-6, and tumour necrosis factor linked to a decrease in myeloperoxidase activity for further research. The findings therefore demonstrated that euphol is useful in the treatment of inflammatory disorders [61]. To evaluate the anti-inflammatory functions of petroleum ether, dichloromethane-methanol, and an aqueous extract of *E. tirucalli* latex, carrageenan-induced paw oedema was employed. Historically, ibuprofen has been considered a common medicine. The results of this study showed that rats' inflammatory oedema was considerably ($P < 0.01$) reduced by petroleum ether, dichloromethane-methanol, and aqueous extracts at doses of 30, 100, and 300 mg/kg, respectively [62].

7.3. Cytotoxicity / Anticancer Activity

Human stomach cancer cells were used to test euphol's antitumor effectiveness. When compared to non-cancerous CSN cells, eupholin showed more cytotoxicity in human stomach CS12 cancer cells. Euphol's anti-proliferative effect was caused by decreased cyclin B1 levels and increased p27kip1 levels. Cell death is caused by PD98059's reduction of ERK1/2 activation, which increases the synthesis of pro-apoptotic proteins triggered by euphol. Through the control of ERK signalling, euphol specifically induces apoptosis in gastric cancer cells, which may be advantageous for cancer treatment [63]. The ethanol extracts of eleven different plants have LD50 values below 1000 ppm: *Cymbopogon nardus*, *Calpurnia pisonis*, *E. bulbosa*, *E. alba*, *E. tirucalli*, *Eryngium foetidum*, *Momordica charantia*, *Millettia hirsutissima*, *Panulirus ornatus*, and *S. microglossa*. *E. tirucalli* and 47 other plant extracts were evaluated for their cytotoxic and

anti-proliferative properties using the MTT assay. To assess the cytotoxic effects of extracts from *Euphorbia antiquorum*, *Egletes humifusa*, *Euphorbia fischeriana*, and *E. tirucalli*, we utilised BEL-7402 (hepatocellular carcinoma) and A-549 (lung cancer) cell lines. The chloroform extract of *Euphorbia tirucalli* and *Euphorbia antiquorum* showed significant cytotoxic effects [64]. Myelogenous leukaemia, glioma, and breast cancer cells were utilised in the investigation. Methotrexate sodium was thought of as the reference medication. Using a time-dependent approach, the IC50 of crude juice was determined to be 10 mL when it was applied to malignant cells. Crude juice effectively stops the most cells in the G1 phase, according to the cell cycle study [65].

utilising mother tincture, a homoeopathic remedy manufactured from *E. tirucalli* was prepared utilising the centesimal Hahnemannian technique. 70GL was used to make ethyl alcohol solutions at 0.5% and 5% concentrations [66]. Treatment with a 0.5% solution of *E. tirucalli* 30 cH resulted in a 32.1% reduction in cell proliferation. The chemical and physical characteristics of LM preparations were evaluated by means of biological techniques and the MTT test. Cell lines MelanA (non-tumoral melanocytes) and MCF-7 (breast cancer) were tested for cytotoxicity by high dilution latex using MTT and May-Grunwald-Giemsa assays. To examine the ultra-structure of the cell, transmission electron microscopy was employed. The enzyme 6-phosphofructo-1-kinase (PFK-1) activity was measured using a spectrophotometric assay. At Aveloz 15 cH, the MCF-7 cell line exhibited enhanced vitality [67].

In their study, Patil and Mugdum discovered that an ethanol extract of the stem bark of *E. tirucalli* had a significant inhibitory effect. Coli was created using dextran sulphate sodium and 2,4,6-trinitrobenzenesulfonic acid. euphol's effects were evaluated by analysing pro-inflammatory mediators and cytokines using immunohistochemistry, ELISA, RT-PCR, and flow cytometry. Myeloperoxidase activity in colonic tissue, histological damage score, and colitis were all significantly reduced by euphol. Additionally, it showed a decrease in the expression of NOS2, VEGF, and Ki67, as well as a decline in the levels of IL-1 β , MCP-1, MIP-2, TNF- α , and IL-6 [68].

7.4. Antiviral Activity

Tobacoviruses, including tobacco and tomato mosaic viruses, were studied to determine if *E. tirucalli* latex extracts in petroleum ether and dichloromethane-methanol were efficacious. The concentrations of the extracts that were used were 50, 100, and 150 ppm. The petroleum ether extract was 80% effective against the tomato mosaic virus at a concentration of 150 parts per million. The dichloromethane-methanol extract was 81% efficient against the tobacco mosaic virus at a concentration of 150 parts per million [69]. Herpes simplex virus type 2's lytic impact was assessed using the end-point titration technique. The most efficient extracts were those of *Euphorbia cotinifolia* and *E. tirucalli* in methanol and water, respectively [70].

7.5. Antioxidant Activity

Euphorbia tirucalli L. has substantial antioxidant activity, with both aqueous and methanolic extracts showing dose-dependent antioxidant, radical scavenging, and reducing power activities. The methanolic extract has almost twice as much antioxidant activity as the aqueous extract. This was due to the high phenolic content. The antioxidant activity was validated using the ABTS, DPPH, CUPRAC, and FRAP tests [71]

7.6. Biofuel Property

Euphorbia tirucalli has appeared and advantageable bioenergy crop because of phenomenal adaptability and marginal environmental conditions, capacity to produce significant biomass and energy-rich substances. This plant grows under drought, salinity, and poor soil conditions. *Euphorbia tirucalli* L. presents unique photosynthetic conditions comprising C3 metabolism in leaves and CAM metabolism in the stem increases water use possibility maintain carbon assimilation during prolonged drought. There is support for biomass accumulation under adverse environmental conditions. Under the optimal growth condition *Euphorbia tirucalli* L. produce approximately 22–25 t ha⁻¹ year⁻¹ of dry biomass, while in mature plantation reported to yield up to 500 t ha⁻¹ of fresh biomass. The latex of this plant contains a good amount of hydrocarbons, sterols, triterpenes, rubber like compound which have been explored as renewable substitutes for petroleum-derived fuels, with an estimated energy equivalent of 10–50 barrels of oil per hectare.[72]

7.7. Biodiesel Property

Euphorbia tirucalli L. grows in semi-arid tropical climates and produces latex containing terpenoids, diterpenes, especially ingenol and phorbol-rich compounds, and other substances capable for the production of biodiesel. Edible crop oils are a limited source, and their prices are very unstable. Non-food medicinal plants like *Euphorbia tirucalli* are an attractive choice for biodiesel making. The latex collected from the plant, and oil extracted from the latex by the transesterification reaction in the presence of a catalyst. It is the primary method of biodiesel production.[73]

8. TOXICITY AND SAFETY CONCERNS

Although *Euphorbia tirucalli* has strong bioactive qualities, its milky latex raises serious safety and toxicity issues. When the latex comes into direct contact with skin, it can produce serious responses including redness, irritation, and blistering. Intense discomfort, conjunctivitis, and in extreme situations, transient visual impairment might result from unintentional eye exposure [74]. As a result, care must be used when handling the plant, particularly when harvesting or preparing medicines.

9. ADVANTAGES OF EUPHORBIA TIRUCALLI L.

The *Euphorbia tirucalli* L. has several aspects that make this plant an interesting multipurpose plant for medicinal, industrial and environmental applications. Its outstanding ability to withstand drought, salinity, and low fertility makes it a valuable option for growing on marginal lands

that cannot be used for food crops. The plant has a high rate of vegetative propagation by stem cutting which makes it easy to be cultivated in large quantities and with low production cost. The diverse array of phytochemicals found in this plant, including terpenoids, triterpenoids, flavonoids, phenolic compounds, and sterols, gives it a broad variety of medicinal uses, including antioxidant, antibacterial, anti-inflammatory, antiviral, and anticancer effects. Moreover, the hydrocarbon-rich latex is a valuable renewable feedstock for producing biofuel, biodiesel, biogas, rubber, and resin, thus promoting sustainable energy generation. The species is also ecologically valuable as a hedge plant, soil erosion control, drought tolerant and for carbon sequestration. In total, these characteristics make *E. tirucalli* a highly valuable medicinal and industrial plant with a great potential for sustainable exploitation."

10. LIMITATIONS

Although *Euphorbia tirucalli* has significant potential for medicinal and industrial uses, it has a number of drawbacks that hinder its broad applications. Its milky latex is very irritating and toxic to the skin, eyes and gastrointestinal tract, making it the major drawback. There are many pharmacological activities reported, but most of the available evidence comes from in vitro studies and experimental animal models with a paucity of well-designed human clinical studies. There is still not enough standardisation in the methods for extracting, in optimising dosage, in quality control and, in the testing of toxicity, which makes reproduction of extracts difficult and restricts therapeutic applications. Also, the phytochemical make up can vary significantly depending on geographical origin, cultivation practices, environmental conditions and extraction methods, which makes it difficult to find consistency in the biological activities reported. Also, although it is well known for its potential as a biofuel, commercial scale cultivation, hydrocarbon extraction, economic viability and life-cycle assessment are not well explored. The restrictions highlight the importance of scientific validation of these plants before they can be fully used in pharmaceutical and industrial industries.

11. FUTURE SCOPE

Euphorbia tirucalli has great potential for future due to its various applications such as medicine, renewable energy, agriculture, and biotechnology. Further research is required to determine the therapeutic activity of this chemical, identify its unique bioactive components, and understand their mechanisms of action. Human trials involving many centers will be necessary to determine the efficacy and safety of this drug. Standardised extraction procedures, quality control guidelines and pharmaceutical formulations may help its incorporation into evidence-based medicine. Metabolomics, genomics, transcriptomics and biotechnology advances could further aid in finding useful phytochemicals and in genetic improvement of biomass production. The sustainable bioenergy nature of bioethanol and biodiesel requires optimization of hydrocarbon extraction, biodiesel

conversion technologies, life-cycle assessment and techno-economic analyses in the renewable energy sector. Furthermore, the development of research related to nanotechnology delivery systems for drug delivery, green synthesis of nanoparticles, antimicrobial coatings, wound-healing formulations and nutraceuticals would be a great addition to its industrial importance. *E. tirucalli* will continue to be recognized as a valuable multipurpose plant with potential applications in global climate change mitigation, climate resilience, and carbon sequestration, as well as in health care and sustainable development, thanks to the long-term ecological studies.

12. CONCLUSION

Euphorbia tirucalli L is a plant with a multiple of uses in medicine and industry. The availability of a variety of phytochemicals in the plant, such as terpenoids, flavonoids, and phenols, accounts for its broad pharmacological actions, which include antioxidant, antimicrobial, anti-inflammatory, and anticancer activity. Besides, traditional medicinal applications in various geographical locations also underscore the plant's significance in treating several diseases. Nevertheless, the toxicity associated with its latex poses substantial health concerns, necessitating careful usage and scientific investigations to establish its medicinal benefits. The cultivation of *Euphorbia tirucalli* L. is relatively easy due to its effective vegetative propagation potential and plant possesses considerable potential as renewable energy source because of its hydrocarbon rich biomass appropriate for biofuel production. Even though current literature documents the existence of numerous biological activities in *E. tirucalli*, most of these claims are at their early stages and warrant additional clinical research. The standardization of extracts, isolation of active compounds, and formulation of safe preparations constitute major areas of future investigations.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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