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Jatropha gossypifolia L.: An Updated Review on Ethnomedicinal Uses, Phytochemistry, Pharmacological Activities and Therapeutic Potential

Dhale D A
Department of Botany, SSVPS's, L.K. Dr P.R Ghogrey Science College, Dhule, Maharashtra, India

Abstract
Jatropha gossypifolia L. (Euphorbiaceae), commonly known as Bellyache Bush or Red Physic Nut, is an important medicinal shrub widely distributed throughout tropical and subtropical regions of the world. The species has been extensively employed in traditional systems of medicine, including Ayurveda, folk medicine, and ethnoveterinary practices, for the management of skin disorders, inflammation, wounds, gastrointestinal ailments, fever, rheumatism, hypertension, and infectious diseases. Different plant parts, including leaves, roots, bark, latex, seeds, and seed oil, contain diverse classes of bioactive compounds such as diterpenoids, flavonoids, lignans, coumarins, alkaloids, steroids, phenolic compounds, and triterpenoids that contribute to its broad spectrum of biological activities. Pharmacological investigations have demonstrated significant antimicrobial, antioxidant, anti-inflammatory, analgesic, wound-healing, hepatoprotective, antidiabetic, anticancer, antiviral, insecticidal, and antihypertensive properties. However, the presence of toxic constituents, particularly phorbol esters and toxalbumins, necessitates careful evaluation of safety before therapeutic application. Recent advances in phytochemical profiling, molecular pharmacology, biotechnology, and nanotechnology have further expanded the pharmaceutical prospects of this medicinal species. The present review critically compiles and updates the available information on taxonomy, botanical description, distribution, traditional medicinal applications, phytochemistry, pharmacological activities, toxicity, and future research perspectives of *Jatropha gossypifolia*. This review highlights existing research gaps and emphasizes the need for standardized phytochemical characterization, mechanistic pharmacological studies, and well-designed clinical investigations to facilitate the development of evidence-based herbal therapeutics.

Keywords: *Jatropha gossypifolia*, Euphorbiaceae, ethnomedicine, phytochemistry, pharmacology, medicinal plants

Introduction

Medicinal plants continue to serve as an indispensable source of healthcare for nearly 80% of the global population, particularly in developing countries where traditional medicine remains an integral component of primary healthcare (World Health Organization [WHO], 2023) [36]. Among the diverse medicinal flora, the family Euphorbiaceae comprises several economically and pharmacologically important genera, of which *Jatropha* is one of the most extensively investigated due to its remarkable medicinal, industrial, and biofuel potential (Webster, 2014) [35].

Jatropha gossypifolia L., commonly known as Bellyache Bush, Red Physic Nut, or Cotton-leaf Jatropha, is a perennial shrub indigenous to tropical America and subsequently introduced into Asia, Africa, and other tropical regions. The plant has become naturalized throughout India, where it commonly grows along roadsides, wastelands, forest margins, agricultural fields, and disturbed habitats (Nadkarni, 1954; Jain, 1965) [20, 26].

The species occupies an important position in traditional medicine owing to its diverse therapeutic applications. Different parts of the plant have been traditionally utilized as purgative, emetic, antimicrobial, anti-inflammatory, analgesic, wound-healing, febrifuge, vermifuge, and blood-purifying agents. Leaves are frequently applied externally to treat eczema, boils, carbuncles, and skin infections, whereas bark decoctions are used for gynecological disorders and digestive ailments. Latex and seed oil are also employed in folk medicine for wound management and musculoskeletal pain (Chopra *et al*., 1956; Jain, 1965). [13, 20]

Scientific investigations conducted over the past several decades have revealed numerous phytoconstituents including flavonoids, diterpenoids, lignans, coumarins, steroids, triterpenoids, phenolic compounds, and essential fatty acids that contribute to the plant's biological activities. Experimental studies have demonstrated antimicrobial, antioxidant, anti-inflammatory, analgesic, anticancer, hepatoprotective, antidiabetic, antiviral, insecticidal, and wound-healing properties, thereby supporting several of its traditional medicinal uses (Subramanian *et al*., 1971; Purushothaman *et al*., 1979; Devappa *et al*., 2010) [14, 28, 33].

Despite extensive ethnomedicinal usage, the therapeutic application of *J. gossypifolia* remains limited due to insufficient clinical validation, variability in phytochemical composition, and the occurrence of toxic diterpene esters. Consequently, comprehensive evaluation of its phytochemistry, pharmacological efficacy, toxicology, and standardization is essential for its safe utilization in modern medicine.

The present review provides an updated synthesis of current knowledge regarding the taxonomy, botanical description, geographical distribution, ethnomedicinal importance, phytochemistry, pharmacology, toxicity, and future research prospects of *Jatropha gossypifolia*, with emphasis on recent scientific advances and evidence-based therapeutic applications.

Botanical Description and Taxonomy

Jatropha gossypifolia is an erect, evergreen to semi-deciduous shrub generally attaining a height of 1–3 m, although under favorable environmental conditions it may

grow up to 4 m. The plant exudes a characteristic purplish-red latex upon injury and possesses reddish-purple stems covered with glandular hairs. Leaves are alternate, palmately three- to five-lobed, ovate to broadly cordate, and dark purplish-green with long petioles bearing glandular stipules. The inflorescence is terminal or axillary cymose, consisting of unisexual flowers that are typically deep red or crimson in color. Fruits are trilocular capsules containing three ellipsoidal seeds, which are rich in fixed oil but also contain toxic phorbol esters. Flowering and fruiting occur throughout most of the year under tropical climatic conditions (Webster, 2014; Acevedo-Rodríguez & Strong, 2012) [2, 35].

Microscopic investigations have shown characteristic laticifers, multicellular glandular trichomes, anisocytic stomata, calcium oxalate crystals, abundant vascular tissues, and well-developed secretory cells, which serve as valuable diagnostic characters for pharmacognostic identification (Krishnamurthy, 1968; Rao & Malaviya, 1964) [22, 23, 29].

Fig 1: Habitat of *Jatropha gossypifolia*

Distribution and Habitat

Jatropha gossypifolia is native to Brazil, Central America, the Caribbean Islands, and tropical South America. Owing to its adaptability and ornamental value, it has been introduced into tropical and subtropical countries throughout Asia, Africa, Australia, and the Pacific Islands, where it has become widely naturalized. In several countries, including India, Australia, and parts of Africa, the species behaves as an invasive weed due to its prolific seed production, efficient dispersal mechanisms, and tolerance to diverse environmental conditions (CABI, 2024) [11].

In India, *J. gossypifolia* is extensively distributed across almost all states, particularly in Maharashtra, Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Telangana, Odisha, West Bengal, Assam, and North-eastern regions. The species thrives in wastelands, roadsides, scrub forests, abandoned agricultural lands, riverbanks, forest margins, and degraded ecosystems, exhibiting remarkable adaptability to dry tropical and subtropical climates (Nadkarni, 1954; Jain, 1965) [20, 26].

The plant grows well in well-drained sandy loam, red soils, and lateritic soils with moderate fertility and tolerates prolonged drought conditions due to its deep root system. It is generally found from sea level up to about 1,500 m elevation and performs optimally under annual temperatures ranging from 20–35°C with moderate rainfall. Its ecological plasticity has enabled the species to colonize disturbed habitats, making it an important component of secondary vegetation in tropical ecosystems (USDA, 2023; CABI, 2024) [11, 34].

Ethnomedicinal Uses

Jatropha gossypifolia L. has long been recognized as an important medicinal plant in Ayurveda, Siddha, Unani, and various indigenous healthcare systems across tropical countries. Different plant parts, including leaves, roots, bark, seeds, latex, and seed oil, are traditionally employed either individually or in combination for the treatment of numerous human and veterinary ailments (Nadkarni, 1954; Chopra *et al*., 1956) [13, 26].

In traditional Indian medicine, fresh leaves are externally applied as poultices over boils, carbuncles, eczema, ringworm, ulcers, wounds, and inflammatory swellings owing to their antimicrobial and anti-inflammatory properties. Leaf decoctions are administered orally to alleviate stomachache, dysentery, constipation, fever, venereal diseases, and as a blood purifier. The bark decoction has been reported to possess emmenagogue properties and is traditionally used for menstrual disorders. Seeds are regarded as strong purgatives and emetics; however, excessive consumption may produce severe toxicity because of the presence of phorbol esters and toxalbumins (Jain, 1965; Nadkarni, 1954) [20, 26].

The latex is widely utilized in folk medicine for the treatment of cuts, wounds, cracked skin, toothache, hemorrhoids, insect bites, rheumatic pain, and fungal infections. Seed oil is traditionally applied as a topical analgesic for muscular pain and joint inflammation and has also been used as an insect repellent in rural communities (Jain, 1965; Dhale and Patil, 2024) [15, 20].

Ethnobotanical surveys conducted in different parts of India, Brazil, Nigeria, Ghana, and other tropical countries have documented the use of *J. gossypifolia* for hypertension, diabetes, malaria, jaundice, gastrointestinal disorders, snakebite, skin infections, reproductive disorders, and parasitic infestations. The plant also plays an important role in ethnoveterinary medicine for treating wounds, ectoparasites, diarrhea, and skin diseases in domestic animals (Burkill, 1994; Jain & Tarafder, 1970; Lans, 2006) [10, 21, 24].

Recent ethnopharmacological investigations indicate that many of these traditional applications are supported by experimental evidence demonstrating antimicrobial, antioxidant, anti-inflammatory, wound-healing, analgesic, hepatoprotective, and antidiabetic activities, thereby validating its extensive use in indigenous healthcare systems (Devappa *et al*., 2010; Sabandar *et al*., 2013) [14, 30].

Phytochemistry

Phytochemical investigations have revealed that *Jatropha gossypifolia* is a rich reservoir of structurally diverse secondary metabolites responsible for its broad pharmacological activities. Various plant organs—including leaves, roots, stem bark, seeds, latex, and fruits—contain diterpenoids, flavonoids, lignans, coumarins, triterpenoids, steroids, alkaloids, tannins, saponins, glycosides, phenolic acids, fatty acids, and proteins.

Early phytochemical studies identified flavonoids such as vitexin, isovitexin, and apigenin in the leaves, whereas the roots yielded novel diterpenoids including jatropholone A

and jatropholone B. Stem bark and roots contain β-sitosterol, β-amyrin, taraxerol, lignans, and coumarino-lignans, while seeds are rich in fixed oils composed mainly of palmitic, stearic, oleic, linoleic, arachidic, and myristic acids. Several phytosterols, including β-sitosterol and its glucosides, have also been isolated from different plant parts (Sinha, 1959a; Mitra *et al*., 1970; Purushothaman *et al*., 1979; Banerji *et al*., 1984) [5, 25, 28, 32].

Advanced chromatographic and spectroscopic techniques such as HPLC, LC–MS/MS, GC–MS, NMR, and FTIR have subsequently identified numerous phenolic compounds and antioxidant metabolites contributing to the plant's antimicrobial and free radical scavenging activities. Quantitative analyses indicate that leaves generally contain higher concentrations of total phenolics and flavonoids than mature fruits and stems, suggesting their greater therapeutic potential (Dogra & Singh, 1983) [19].

Recent metabolomic investigations have also reported the occurrence of diterpene esters, cyclic peptides, terpenoids, phytosterols, and various antioxidant polyphenols that collectively contribute to anti-inflammatory, anticancer, hepatoprotective, and antimicrobial activities. However, toxic phorbol esters remain a major concern, limiting the direct medicinal use of crude seed preparations and emphasizing the need for purification and standardization before pharmaceutical development (Devappa *et al*., 2010; Sabandar *et al*., 2013) [14, 30].

Overall, the remarkable chemical diversity of *J. gossypifolia* makes it an important source of bioactive molecules with promising applications in herbal drug development and pharmaceutical research.

Pharmacognosy

Pharmacognostic evaluation is essential for ensuring the correct identification, authentication, quality control, and standardization of herbal drugs derived from *Jatropha gossypifolia*. The species possesses several distinctive macroscopic and microscopic characteristics that differentiate it from closely related members of the genus *Jatropha*.

Macroscopically, *J. gossypifolia* is an erect shrub measuring approximately 1–3 m in height with reddish-purple stems containing abundant latex. Leaves are alternate, palmately three- to five-lobed, cordate at the base, and covered with characteristic glandular hairs. Flowers are unisexual, bright crimson to purplish-red, arranged in terminal cymes, while fruits are trilocular capsules containing three ellipsoidal seeds. The characteristic purplish-red latex exuded from injured tissues serves as an important diagnostic feature (Rao & Malaviya, 1964) [29].

Microscopic examination reveals a single-layered epidermis with anisocytic stomata, multicellular glandular trichomes, abundant laticifers, calcium oxalate crystals, well-developed vascular bundles, and parenchymatous cortex. Histomorphological studies comparing *J. gossypifolia* with *J. glandulifera* and *Ricinus communis* demonstrated significant differences in epidermal architecture and latex characteristics, facilitating accurate botanical identification (Krishnamurthy, 1968; Rao & Malaviya, 1964) [22, 23, 29].

Powder microscopy of dried leaves reveals fragments of multicellular trichomes, spiral xylem vessels, lignified fibers, calcium oxalate crystals, starch grains, pollen grains, and latex-containing secretory cells, which serve as important diagnostic markers during crude drug authentication. Physicochemical parameters including total ash, acid-insoluble ash, extractive values, moisture content, and fluorescence characteristics have been recommended for quality control and pharmacopoeial standardization.

Modern pharmacognostic approaches involving scanning electron microscopy (SEM), DNA barcoding, HPTLC fingerprinting, LC–MS profiling, and chemometric analysis have significantly improved the authentication and quality assessment of *J. gossypifolia*. These advanced techniques facilitate the detection of adulteration, ensure batch-to-batch consistency, and support the development of standardized herbal formulations suitable for pharmaceutical applications.

Pharmacological Activities

Extensive pharmacological investigations have validated several traditional medicinal claims associated with *Jatropha gossypifolia* L. Different extracts prepared from leaves, roots, bark, seeds, latex, and the whole plant exhibit a wide spectrum of biological activities attributable to the presence of flavonoids, diterpenoids, lignans, phenolic compounds, steroids, triterpenoids, and other secondary metabolites. Experimental studies have demonstrated antimicrobial, antioxidant, anti-inflammatory, analgesic, wound-healing, hepatoprotective, anticancer, antiviral, insecticidal, antihypertensive, and central nervous system activities, highlighting the pharmaceutical significance of this species (Sabandar *et al*., 2013; Devappa *et al*., 2010) [14, 30].

Antimicrobial activity is one of the most extensively investigated pharmacological properties of *J. gossypifolia*. Various solvent extracts have exhibited inhibitory effects against several Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Salmonella typhi*, and *Pseudomonas aeruginosa*, as well as pathogenic fungi such as *Candida albicans* and *Aspergillus* species. These activities are primarily attributed to phenolic compounds, flavonoids, and diterpenoids that interfere with microbial cell wall integrity and metabolic processes (Dhale and Birari, 2010; Sabandar *et al*., 2013) [16, 30].

The plant also exhibits remarkable anti-inflammatory and analgesic activities. Experimental animal studies have demonstrated that ethanolic and methanolic leaf extracts significantly reduce carrageenan-induced paw edema and inhibit inflammatory mediators, thereby supporting their traditional use in treating rheumatism, swelling, wounds, and painful conditions. Antioxidant investigations further indicate strong free radical scavenging activity through modulation of oxidative stress and enhancement of endogenous antioxidant enzymes (Devappa *et al*., 2010) [14].

Several investigations have reported promising wound-healing activity of latex and leaf extracts by accelerating collagen synthesis, epithelialization, angiogenesis, and tissue remodeling. These findings substantiate the widespread ethnomedicinal use of the plant for treating cuts, burns, ulcers, boils, and skin infections.

Early pharmacological investigations demonstrated hypotensive and cardiovascular effects of seed extracts. Glycosidal fractions isolated from *J. curcas* seeds significantly reduced blood pressure and altered smooth muscle activity in experimental animals, whereas extracts of *J. gossypifolia* exhibited central nervous system depressant effects and potentiation of barbiturate-induced hypnosis

without significant cardiovascular toxicity at therapeutic doses.

Recent studies have also demonstrated hepatoprotective, antidiabetic, cytotoxic, anticancer, antiviral, larvicidal, insecticidal, and antiparasitic activities. Several diterpenoids and flavonoids have shown selective cytotoxicity against human cancer cell lines through induction of apoptosis and inhibition of cell proliferation. In addition, extracts of *Jatropha* species have demonstrated antiviral activity against selected RNA viruses and mosquito larvicidal activity against *Aedes aegypti*, indicating potential applications in public health and vector control (Aswal *et al*., 1984; Babbar *et al*., 1982) [3, 4].

Despite these promising biological activities, further investigations involving molecular mechanisms, pharmacokinetic profiling, toxicity evaluation, and well-designed clinical trials are required before *J. gossypifolia*-based therapeutics can be recommended for clinical use.

Toxicology and Safety

Although *Jatropha gossypifolia* possesses considerable medicinal value, it is also recognized as a toxic plant because of the presence of phorbol esters, toxalbumins (curcin-like proteins), diterpenoids, and other biologically active compounds. Toxicity varies among plant parts, with seeds and latex generally exhibiting the highest toxic potential (Devappa *et al*., 2010) [14].

Accidental ingestion of seeds may produce severe gastrointestinal disturbances characterized by nausea, vomiting, abdominal pain, diarrhea, dehydration, and electrolyte imbalance. In severe poisoning cases, neurological manifestations including dizziness, muscular weakness, hypotension, respiratory depression, and convulsions have been reported. Experimental studies indicate that excessive doses may cause hepatic and renal damage due to oxidative stress and tissue necrosis (Sabandar *et al*., 2013) [30].

Historical pharmacological investigations demonstrated dose-dependent toxicity of ethanolic extracts in laboratory animals. The reported intraperitoneal LD_{50} values ranged from approximately 375 to 1000 mg/kg depending on the plant part, extraction solvent, and experimental model. Whole-plant extracts produced central nervous system depression, whereas stem bark extracts exhibited comparatively lower toxicity.

Latex may cause skin irritation, allergic dermatitis, conjunctival inflammation, and mucosal irritation upon direct contact. Consequently, handling of fresh plant material requires appropriate protective measures, particularly during extraction and processing.

Modern toxicological assessments emphasize that medicinal preparations derived from *J. gossypifolia* should undergo rigorous phytochemical standardization, toxicity profiling, and dose optimization before clinical application. Isolation of pharmacologically active constituents with reduced toxicity, together with advanced drug-delivery systems, may significantly improve the therapeutic safety of this medicinal species.

Biotechnological and Pharmaceutical Applications

Recent advances in biotechnology and pharmaceutical sciences have considerably expanded the medicinal potential of *Jatropha gossypifolia*. Tissue culture techniques, micropropagation, metabolite enhancement, molecular characterization, and nanotechnology are increasingly being explored for the sustainable utilization and commercial development of this species.

Micropropagation protocols using nodal explants and shoot tip cultures have facilitated rapid clonal multiplication, conservation of elite germplasm, and year-round production of genetically uniform planting material. *In vitro* culture systems also provide opportunities for enhancing the production of valuable secondary metabolites through elicitation, cell suspension cultures, hairy root cultures, and metabolic engineering.

Modern molecular tools such as DNA barcoding, RAPD, ISSR, SSR, and next-generation sequencing have improved species authentication, assessment of genetic diversity, and conservation planning. These approaches contribute significantly to the prevention of adulteration in herbal medicines and support quality assurance during commercial production.

Pharmaceutical research has increasingly focused on isolating bioactive compounds from *J. gossypifolia* for the development of novel therapeutic agents. Flavonoids, diterpenoids, lignans, and phenolic compounds have shown potential as antimicrobial, antioxidant, anti-inflammatory, anticancer, and hepatoprotective drug candidates. Nanoformulations incorporating plant extracts or purified phytochemicals have demonstrated improved bioavailability, enhanced stability, targeted drug delivery, and reduced toxicity compared with conventional herbal preparations.

Green synthesis of metallic nanoparticles using *Jatropha* extracts has emerged as a promising area of research. Silver, zinc oxide, and gold nanoparticles synthesized from plant extracts have demonstrated enhanced antimicrobial, antioxidant, anticancer, and catalytic activities, opening new possibilities for biomedical and pharmaceutical applications.

Furthermore, metabolomics, molecular docking, network pharmacology, and artificial intelligence-assisted drug discovery are being increasingly employed to identify novel lead molecules from *J. gossypifolia*. These interdisciplinary approaches facilitate target identification, mechanism elucidation, and rational drug design, thereby accelerating the translation of traditional medicinal knowledge into evidence-based therapeutics.

Overall, the integration of biotechnology, phytochemistry, pharmacology, and pharmaceutical sciences is expected to significantly enhance the medicinal and commercial value of *J. gossypifolia*, while ensuring sustainable utilization and safe development of standardized herbal formulations.

Conclusion

Jatropha gossypifolia L. is an important medicinal shrub of the family Euphorbiaceae that has been extensively utilized in traditional healthcare systems across tropical and subtropical regions. The present review demonstrates that the plant possesses remarkable ethnomedicinal significance supported by a wide spectrum of phytochemicals, including flavonoids, diterpenoids, lignans, coumarins, phenolics, steroids, and triterpenoids, which contribute to its diverse biological activities. Traditional applications in the treatment of skin diseases, inflammation, gastrointestinal disorders, wounds, fever, rheumatism, hypertension, and microbial infections are increasingly being validated through experimental pharmacological studies.

Modern scientific investigations have confirmed antimicrobial, antioxidant, anti-inflammatory, analgesic, wound-healing, hepatoprotective, antiviral, insecticidal, anticancer, and antihypertensive properties, highlighting the considerable therapeutic potential of this medicinal species. However, the occurrence of toxic constituents, particularly phorbol esters and toxalbumin-like proteins, necessitates careful toxicological evaluation and standardization before its incorporation into evidence-based clinical practice.

Recent advances in phytochemical profiling, metabolomics, molecular pharmacology, biotechnology, nanotechnology, and computational drug discovery have created new opportunities for the identification of novel bioactive molecules and the development of standardized herbal formulations. Nevertheless, several research gaps remain, including comprehensive phytochemical standardization, elucidation of molecular mechanisms of action, pharmacokinetic investigations, long-term toxicity assessments, and well-designed preclinical and clinical studies.

Overall, *Jatropha gossypifolia* represents a valuable medicinal plant with significant pharmaceutical potential. Future multidisciplinary research integrating ethnobotany, phytochemistry, pharmacology, biotechnology, and clinical sciences will facilitate the sustainable utilization and development of safe, effective, and scientifically validated phytopharmaceuticals from this species.

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