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Review Article

Jatropha gossypiifolia L.: Pharmacognostic, Phytochemical, and Pharmacological Insights

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Abstract

Jatropha gossypiifolia L., a species within the Euphorbiaceae family, possesses considerable ethnobotanical relevance across various global regions. Historically, diverse parts of the plant, including leaves, roots, and latex, have been employed in folk medicine for conditions such as inflammation, dysentery, infections, and snakebites. Phytochemical investigations have revealed a complex array of secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, saponins, phenols, steroids, and cardiac glycosides. These chemical constituents underpin a broad spectrum of pharmacological activities. Experimental studies have demonstrated antimicrobial efficacy against both Gram-positive and Gram-negative bacteria, as well as fungi, supporting its traditional use in treating infections. Furthermore, research indicates cytotoxic effects against various cancer cell lines, suggesting potential for anticancer drug development, particularly with compounds like jatrophone. Other reported activities encompass antiophidic effects, antiviral properties, and insecticidal action, highlighting its diverse biological utility. Despite its therapeutic promise, the inherent toxicity of *J. gossypiifolia*, largely attributed to compounds such as phorbol esters, necessitates careful consideration. Comprehensive toxicological assessments are therefore paramount for validating its safe use and for the development of standardized herbal preparations. This review consolidates findings to provide a foundation for future research aimed at isolating novel bioactive molecules and establishing evidence-based medicinal applications for *J. gossypiifolia*.

Keywords: *Jatropha gossypiifolia;* Phytochemistry; Pharmacological activity, Traditional medicine, *J. gossypiifolia*.

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1. Introduction

Plants have long served as a fundamental source of therapeutic agents, forming the basis of traditional medicine systems worldwide and contributing significantly to modern pharmacology. The vast biodiversity of plant species offers an expansive reservoir of secondary metabolites with diverse chemical structures and biological activities [1,2]. Among these, the genus Jatropha, belonging to the Euphorbiaceae family, has garnered considerable attention due to its widespread traditional uses and a growing body of scientific evidence supporting its medicinal potential. The name "Jatropha" itself, derived from Greek words "Jatros" (doctor) and "trophe" (nutrition), alludes to its historical therapeutic applications [3].

Jatropha gossypiifolia L., commonly known as "bellyache bush" or "cotton-leaf physicnut," is a particularly prominent species within this genus. Native to Central and South America, it has naturalized and is widely distributed across tropical and subtropical regions, including Africa and Asia. Traditional medicine systems have long utilized various parts of J. gossypiifolia for a spectrum of ailments. These include its use as an anticoagulant, antihypertensive, anti-inflammatory, antibacterial, antiviral, and antifungal agent. Specific applications range from treating pneumonia,

dysentery, and inflammation to managing snakebites and other infectious diseases [4].

Contemporary scientific exploration of *J. gossypiifolia* seeks to validate these traditional claims through rigorous phytochemical analysis and pharmacological investigations. Such research is crucial for identifying the bioactive compounds responsible for its medicinal effects, understanding their mechanisms of action, and assessing the safety profile of the plant. While the plant offers significant therapeutic potential, it is also recognized for its toxic characteristics, which necessitates careful study and elucidation of its constituents. This article synthesizes existing knowledge on the pharmacognostic features, phytochemical composition, and pharmacological activities of J. gossypiifolia [5,6]. By consolidating these scientific findings, a clearer understanding of its therapeutic utility and the necessary considerations for its development as a source of novel medicinal agents can emerge.

Herbal medicines show promise with diverse therapeutic effects but face challenges like limited clinical trials, complex standardization, and potential interactions. Rigorous research and careful regulation are essential to ensure their safety, efficacy, and integration into modern healthcare [7].

2. Pharmacognostic study of Jatropha gossypiifolia

Pharmacognosy involves the study of medicinal drugs derived from natural sources, focusing on their identification, cultivation, collection, preparation, and standardization. Jatropha gossypiifolia is a well-recognized species within this field due to its established traditional uses and distinct morphological characteristics [8,9].

2.1 Morphological Characteristics

Jatropha gossypiifolia is an ornamental and medicinal plant, native to Central and South America, but now widely distributed. It is characterized by its "bellyache bush" moniker, reflecting its traditional use in purgative applications. The plant typically exhibits a shrubby habit. Its leaves are distinct, often described as cotton-leaf-like, and are particularly important for identification. The flowers are frequently noted for their shiny red color, which contributes to its ornamental value. Various parts of the plant, including leaves, roots, latex, seeds, and fruits (Figure 1) are used in traditional preparations. The species has adapted well to diverse environmental conditions, allowing it to grow and bloom successfully in various regions [10-12].

Figure 1: Parts of *Jatropha Gassypiifolia L.* plant

2.2 Phytochemistry study of *Jatropha gossypiifolia*

The medicinal attributes of Jatropha gossypiifolia are intrinsically linked to its complex phytochemical composition. Extensive research has focused on isolating and characterizing the secondary metabolites present in various parts of the plant, which are responsible for its observed biological activities. These phytochemicals are derived from different plant parts, including leaves, stems, roots, and latex, and serve as direct medicinal agents or lead molecules for drug development. Jatropha gossypiifolia L. contains a diverse range of chemical constituents [13,14], including; in Table 1 and the structure of some selective phytochemicals depicted in Figure 2.

Table 1: Phytochemicals present in *Jatropha Gassypiifolia L.*:

Class	Major Compounds	Biological Role	Referance
Phenolic compounds	Gallic acid, chlorogenic acid, catechin, caffeic acid, vanillic acid, p-coumaric acid, ferullic acid, rutin, quercitrin, trans-cinnamic acid, quercetin, luteolin, apigenin, kaempferol, chrysin.	Antioxidants, anti-inflammatory, anticancer, antimicrobial, and cardioprotective.	[10,14,15]
Triterpenic compounds	α-amyrin, β amyrin, and lupeol.	Anti-inflammatory, antioxidant, anti-cancer, antidiabetic and cardioprotective.	[10,16,17]
Flavonoids and flavones	Orientin, isoorientin, vitexin, isovitexin, luteolin-7-O-glucoside, isoquercitrin, quercetin, apigenin, kaempferol, luteolin.	Modulate inflammation, oxidative damage, and cellular signaling pathways.	[10,14,18,19]
Fatty acids	α-linolenic acid, linoleic acid, palmitic acid, oleic acid, stearic acid, stearidonic acid.	Diverse roles in cell structure, signaling, metabolism, inflammation.	[10,20,21]
Alkaloids	Jatrophine (predominant in bark), Jatrophan, Gadain, Prasanthaline, Arylnapthalene derivatives, Gossypifan, Jatrodien, Gossypiline, Gossypidien, Isogadain, 4'-O-Demethyl retrochinensin (noted in stems)	Analgesic, anti-inflammatory, antimicrobial, antioxidant, and anticancer.	[22-25]
Other compounds	Amino acids, coumarins, steroids, lignans, proteins, saponins, tannins, terpenoids, quinic acid, scopoletin, jasmonic acid, hydroxyoctadecatrienoic acid, hydroxyoctadecadienoic acid, dodecanedioic acid, undecanedioic acid, naringenin.	Antioxidant enzyme inhibition, gene expression modulation, antimicrobial, antidiabetic, anti-inflammatory, metabolism and neuroprotective.	[25-28]

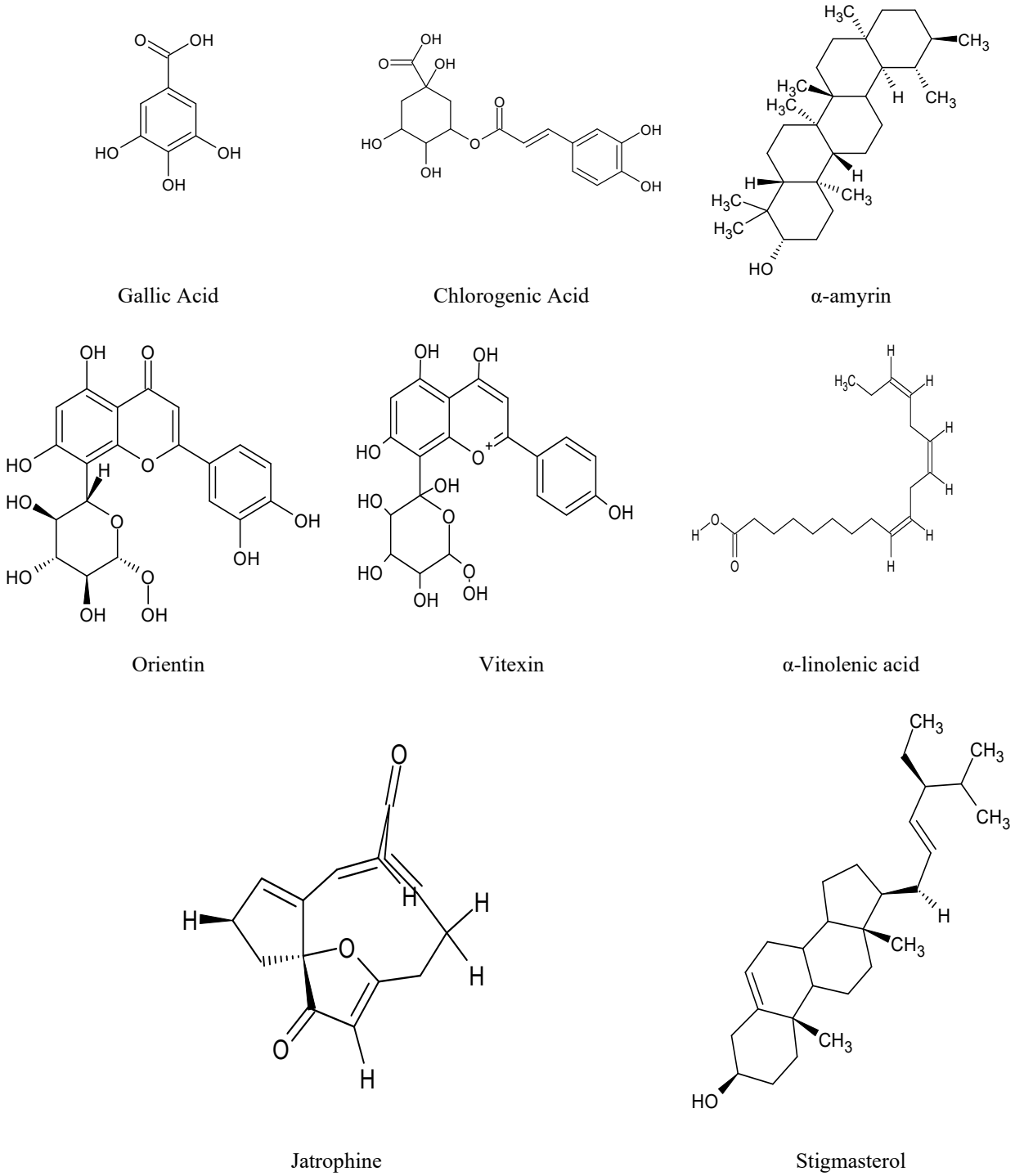

Figure 2: Selective phytochemicals of Jatropha gossypiifolia

3. Pharmacological aspect of *Jatropha Gassypiifolia* L.:

The traditional uses of *Jatropha gossypiifolia* are substantiated by a growing body of pharmacological research demonstrating diverse biological activities. These activities are primarily attributed to the complex array of secondary metabolites identified within the plant [15,16].

3.1 Antimicrobial Activity

Extracts of J. gossypiifolia have exhibited significant antimicrobial efficacy against a range of pathogens. Ethanol extracts of both leaves and root bark have shown concentration-dependent antimicrobial activity against bacteria such as *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Bacillus subtilis*, as well as the fungus Candida albicans. Minimum Inhibitory

Concentration (MIC) values typically range from 50 to 260 mg/ml against susceptible organisms [17-19].

Studies have also confirmed activity against multi-drug resistant isolates, including Acinetobacter baumannii, Enterobacter agglomerans, and Proteus mirabilis, with zones of inhibition varying from 0 to 15 mm. The highest zone of inhibition for *J. gossypiifolia* extracts was observed against Candida albicans, reaching 29 ± 1.414 mm at 100 mg/ml. This broad-spectrum antimicrobial action supports the traditional use of the plant in treating various infections and suggests its potential as a source for novel antimicrobial agents [20-22].

3.2 Anti-inflammatory Activity

J. gossypiifolia possesses anti-inflammatory properties, aligning with its traditional use in managing inflammatory conditions. While direct studies on *J. gossypiifolia's* anti-inflammatory mechanisms are ongoing, related species like *Jatropha cordata* have shown promising results. Ethyl acetate extracts of *J. cordata* bark, for example, demonstrated significant inhibition of nitric oxide (NO) production in LPS-activated RAW 264.7 macrophage cells without affecting cell viability. This suggests that the anti-inflammatory effect may involve modulating inflammatory mediators. Additionally, Jatropha multifida ethanolic leaf extracts demonstrated anti-inflammatory effects in carrageenan and histamine-induced paw edema models in rats, indicating a potential for similar mechanisms within the genus [23-25].

3.3 Anticancer Activity

Research indicates the cytotoxic potential of *J. gossypiifolia*, particularly through specific compounds. Jatrophone, isolated from the stem bark, has shown potent cytotoxic activity against various human cancer cell lines. For instance, jatrophone exhibited an IC50 value of 3.2 µM against human liver cancer cell line Hep G2 1886, which compares favorably to standard anticancer agents like sorafenib and arsenic trioxide. It also demonstrated activity against human colon cancer (WiDr), cervical cancer (HeLa), and stomach cancer (AGS) cell lines with IC50 values of 8.97, 5.13, and 2.5 µM, respectively. This suggests that *J. gossypiifolia*, through compounds like jatrophone, represents a promising candidate for anticancer drug discovery [26-28].

3.4 Antiophidic Activity

One significant traditional application of *J. gossypiifolia* is in the treatment of snakebites. Scientific studies have evaluated the antiophidic properties of its aqueous leaf extract, confirming its ability to counteract the effects of snake venom. The extract effectively inhibited enzymatic and biological activities induced by Bothrops jararaca snake venom both in vitro and in vivo [29,30].

Specific effects included the inhibition of blood incoagulability, reduction of hemorrhagic effects (up to 56%), and complete inhibition of edematogenic local effects when administered orally or intraperitoneally. The extract also nearly achieved 100% inhibition of myotoxic action. The antiophidic activity is potentially mediated by the inhibition of snake venom metalloproteinases (SVMPs) and serine proteinases (SVSPs), including fibrinogenolytic enzymes and thrombin-like enzymes, as well as catalytically inactive phospholipases A2 (Lys49 PLA2). Protein precipitating and antioxidant activities may also contribute to these effects [31,32].

3.5 Insecticidal and Larvicidal Activity

J. gossypiifolia also possesses insecticidal properties. Ethanolic senescent leaf extracts (SLEs) have demonstrated antifeedant effects on larvae of the noctuid pest Spodoptera frugiperda (armyworm larvae). While acute toxicity via topical application was relatively low, mixtures of J. gossypiifolia SLE with cypermethrin exhibited a strong synergistic effect, suggesting its utility in integrated pest management. The SLEs also inhibited P450, general esterase, and acetylcholinesterase activities both in vitro and in vivo, which are key detoxification enzymes in insects [33]. Furthermore, acetone leaf extracts of *J. gossypiifolia* have shown larvicidal efficacy against third and fourth stage Culex quinquefasciatus larvae. Larval mortality increased with extract concentration, with acetone extract demonstrating the highest mortality at 10 mg/ml (85% for third-stage larvae). Low LC_{50} and LC_{90} values for acetone leaf extract indicate its effectiveness, positioning J. gossypiifolia as a potential natural alternative for mosquito control. The insecticidal properties are partly attributed to toxic proteins found in the plant [34,35].

3.6 Other Activities

J. gossypiifolia has also been associated with antiviral activity and has been traditionally used as an antihypertensive and anticoagulant. The presence of diverse phytochemicals, including phenols and flavonoids, also contributes to its antioxidant capacity [36-38].

4. Specific Compounds and Analytical Techniques

Beyond broad classifications, specific bioactive molecules have been isolated and characterized. For instance, jatrophone, a compound isolated from the stem bark of J. gossypiifolia, has demonstrated significant cytotoxic activities against various human cancer cell lines, including Hep G2 liver cancer cells [39,40].

Advanced analytical methodologies are employed for the extraction and analysis of these bioactive compounds. Techniques such as High-Performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), Gas Chromatography-Mass Spectrometry (GC-MS),

and Nuclear Magnetic Resonance (NMR) spectroscopy are routinely used for qualitative and quantitative estimation. For example, GC-MS analysis of Jatropha cordata, a related species, identified fatty acids, fatty esters, phytosterols, alkanes, vitamin E, and terpenoids in hexane extracts, and similar constituents in ethyl acetate and methanolic extracts. While these findings are for a different Jatropha species, they illustrate the type of diverse chemical constituents that are typically found within the genus.

The presence of such a rich and varied phytochemical profile provides a strong basis for the observed pharmacological activities of J. gossypiifolia, simultaneously presenting challenges and opportunities for drug discovery. The identification of specific compounds, like jatrophone, underscores the potential for targeted therapeutic development [41,42].

5. Future Scope

Despite the extensive research on *Jatropha gossypiifolia*, several avenues for future investigation remain unaddressed, presenting opportunities for novel discoveries and the enhanced utilization of this plant. A thorough scientific exploration of its full potential requires a multi-faceted approach, balancing its therapeutic promise with concerns regarding toxicity.

6. Conclusion

Jatropha gossypiifolia L. stands as a plant of significant ethnobotanical and pharmacological interest, embodying a rich history of traditional medicinal application across various cultures. This review synthesized the available scientific evidence, highlighting its complex phytochemical composition and a broad spectrum of experimentally validated biological activities. The plant's therapeutic attributes are attributable to a diverse array of secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, saponins, phenols, steroids, and cardiac glycosides. Despite these promising findings, the inherent toxicity associated with certain Jatropha species, including *J. gossypiifolia,* necessitates a cautious approach. The presence of toxic compounds, such as phorbol esters, mandates rigorous toxicological studies to fully characterize its safety profile and establish safe therapeutic dosages. Moving forward, research efforts should prioritize the elucidation of molecular mechanisms of action, the isolation of novel bioactive compounds, and, critically, the conduct of comprehensive clinical trials to validate efficacy and safety in humans. The integration of traditional knowledge with modern scientific inquiry provides a robust framework for unlocking the full medicinal benefits of *J. gossypiifolia*. Through continued, systematic research, this plant could yield valuable contributions to the development of new pharmaceutical agents, particularly in areas facing challenges such as antibiotic resistance or the need for novel anticancer treatments. However, such progress must be underpinned by a thorough understanding of its complex pharmacology and toxicology to ensure responsible and effective utilization.

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All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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All authors agree to publish the article.

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