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Phytochemical Evaluation and In Vitro Antifibrotic Potential of *Jatropha maheshwarii*: A Comprehensive Review

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ABSTRACT

Fibrosis is a progressive pathological process characterized by excessive deposition of extracellular matrix components, leading to organ dysfunction. Natural products have gained attention as potential antifibrotic agents due to their multi-targeted mechanisms and lower toxicity. *Jatropha maheshwarii*, a member of the Euphorbiaceae family, has been traditionally used in folk medicine and recently explored for its in vitro antifibrotic activity. This review critically compares available literature and summarizes the botanical features, ethnomedical relevance, phytochemical profile, and in vitro evidence supporting the antifibrotic potential of *Jatropha maheshwarii*. Future perspectives on in vivo validation and translational research are also discussed.

The present study was designed to evaluate the anti-fibrotic potential of the test sample using in vitro experimental models. Anti-fibrotic activity was assessed in activated hepatic stellate cell lines by measuring cell viability, collagen accumulation, and the expression of key fibrotic markers, including α-smooth muscle actin (α-SMA), transforming growth factor-β (TGF-β), and collagen type I. The test sample exhibited significant inhibition of fibrotic marker expression and reduced collagen deposition in a dose-dependent manner without showing cytotoxicity at effective concentrations. These findings suggest that the sample possesses promising anti-fibrotic properties and may serve as a potential therapeutic candidate for the management of fibrosis-related disorders. Further studies are required to confirm its efficacy through in vivo models and mechanistic investigations.

Keywords: Anti-fibrotic activity, *Jatropha maheshwarii*, TGF-β, α-SMA, flavonoids, phenolics, anti-oxidant.

1. INTRODUCTION

Fibrosis represents a common end-stage pathway of chronic inflammatory diseases affecting organs such as liver, lung, kidney, and heart. Activation of fibroblasts and their differentiation into myofibroblasts, driven by profibrotic mediators such as transforming growth factor-β (TGF-β), result in excessive collagen deposition and tissue remodeling. Despite advances in antifibrotic therapy, currently available drugs remain limited in efficacy and are associated with adverse effects[1]. Consequently, there is increasing interest in plant-derived compounds as alternative antifibrotic agents. *Jatropha maheshwarii*, an endemic species of the genus *Jatropha*, has emerged as a promising candidate based on preliminary in vitro studies[2].

The genus *Jatropha* (family: Euphorbiaceae) comprises a wide variety of medicinally important plants widely distributed in tropical and subtropical regions. Several *Jatropha* species have been traditionally used in folk medicine for the treatment of inflammation, skin disorders, wound healing, liver ailments, and infections[3]. Among them, *Jatropha* plants are known to be rich sources of bioactive phytochemicals such as diterpenoids, flavonoids, phenolic compounds, lignans, and triterpenes, which contribute to their diverse pharmacological activities[4].

Fibrosis is a chronic pathological condition characterized by excessive accumulation of extracellular matrix proteins, mainly collagen, leading to tissue scarring and progressive organ dysfunction[5]. Liver fibrosis, in particular, is a major global health concern and can progress to cirrhosis and hepatocellular carcinoma if left untreated. Current therapeutic strategies for fibrosis remain limited, creating a strong need for safer and more effective anti-fibrotic agents. Natural products and medicinal plants have gained significant attention in anti-fibrotic drug development due to their multi-target mechanisms and lower toxicity profiles[6].

In recent years, *Jatropha* species have emerged as promising candidates for anti-fibrotic research due to their strong antioxidant, anti-inflammatory, and hepatoprotective properties. These activities are crucial in preventing fibrotic progression, as oxidative stress

and inflammatory signalling pathways play a key role in the activation of hepatic stellate cells (HSCs), which are the primary mediators of collagen deposition and fibrosis development. Phytoconstituents from *Jatropha* have been reported to modulate important fibrotic pathways such as transforming growth factor-β (TGF-β), α-smooth muscle actin (α-SMA), and collagen synthesis, thereby inhibiting extracellular matrix accumulation and fibrotic tissue remodeling[7].

Therefore, the *Jatropha* plant represents an important natural source for exploring novel anti-fibrotic compounds[8]. The investigation of its extracts and bioactive constituents may provide valuable leads for the development of plant-based anti-fibrotic drugs, particularly targeting liver fibrosis. Further scientific validation through in vitro and in vivo studies is essential to establish its therapeutic potential and to understand its molecular mechanisms of action[9].

2. BOTANICAL DESCRIPTION AND TAXONOMY

- *Jatropha maheshwarii* belongs to the family Euphorbiaceae and the genus *Jatropha*, which comprises more than 170 species distributed mainly in tropical and subtropical regions.

- The plant is a perennial shrub characterized by erect stems, large palmately lobed leaves, and small unisexual flowers arranged in cymose inflorescences.

- The fruits are trilocular capsules containing oily seeds.

- Taxonomically, *Jatropha maheshwarii* is distinguished from other *Jatropha* species by its unique leaf morphology and floral characteristics[10].



Figure 1. Jatropha maheshwarii

2.1 Taxonomy

Table 1: Taxonomy of Jatropha maheshwarii

Taxonomic Rank	Classification
Kingdom	Plantae
Phylum (Division)	Streptophyta (Angiosperms)
Class	Equisetopsida (Magnoliopsida – Dicotyledons)
Subclass	Magnoliidae
Order	Malpighiales
Family	Euphorbiaceae
Subfamily	Crotonoideae
Tribe	Jatropheae
Genus	*Jatropha*
Species	*Jatropha maheshwarii* Subram. & M.P. Nayar

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3. MORPHOLOGY

3.1 Habit



Figure 2 & Figure 3. Habit of Jatropha maheshwarii

Jatropha maheshwarii is a perennial undershrub or small shrub, typically growing about 1.5–2 m in height, though some reports mention it may reach higher under favorable conditions. It belongs to the family Euphorbiaceae and exhibits a succulent, drought-resistant growth habit. The plant is well adapted to tropical coastal regions, particularly in Tamil Nadu and Kerala, where it thrives in sandy or lateritic soils[11].

Morphologically, it shows a caudiciform nature, meaning it has a swollen basal stem (caudex) which helps in water storage and survival in dry conditions. This feature gives the plant a distinctive appearance compared to other shrubs[12].

3.2 Root System and Caudex

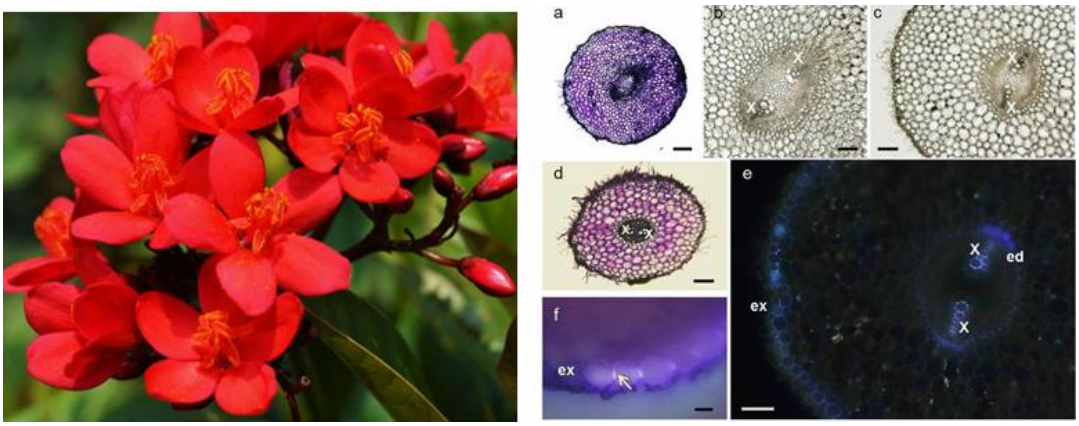


Figure 4 & Figure 5. Root system and caudex of Jatropha maheshwarii

The root system is well-developed and adapted to dry environments, often associated with a prominent caudex (swollen basal stem). This caudex may reach up to 25–30 cm in thickness, functioning as a storage organ for water and nutrients.

The roots penetrate porous soils efficiently, allowing the plant to withstand drought stress. This morphological adaptation is a key survival strategy in its natural habitat[13].

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3.3 Stem Characteristics



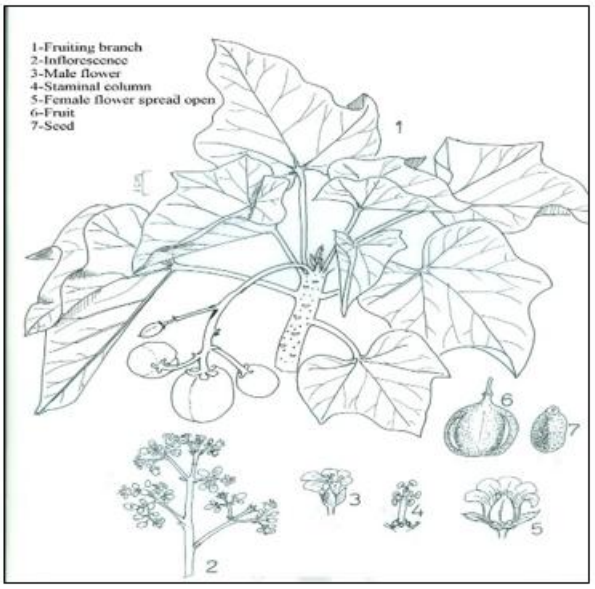


Figure 6 & Figure 7. Stem of Jatropha maheshwarii

The stem is thick, fleshy, and somewhat succulent, arising from the caudex. It is usually green to brownish, smooth, and branched. Like other members of the genus *Jatropha*, the stem may contain latex (milky sap), which is a characteristic feature of Euphorbiaceae plants.

The branching pattern is irregular, forming a compact shrub canopy. The succulent nature of the stem aids in water conservation[14].

3.4 Leaves





Figure 8 & Figure 9. Leaves of Jatropha maheshwarii

Leaves are simple, alternate, and petiolate, showing considerable variation in shape. Typically, they are:

- Broad and ovate to palmately lobed
- With a smooth or slightly glossy surface
- Attached by a long petiole, sometimes joining near the middle of the leaf blade (a distinctive feature noted in specimens)

The leaves are adapted for efficient photosynthesis and may show morphological variability, which is common within the genus[9].

3.5 Inflorescence and Flowers



Figure 10. Inflorescence and flowers of Jatropha maheshwarii

The flowers are borne in terminal or axillary clusters (inflorescences). They are typically:

- Small and unisexual (separate male and female flowers)
- Brightly colored, often yellow or red with contrasting centers
- Composed of five sepals and five petals, with multiple stamens in male flowers

These flowers are attractive and contribute to the plant's ornamental value. Flowering is generally seasonal and influenced by environmental conditions[15].

3.6 Fruits and Seeds



Figure 11. Fruits of Jatropha maheshwarii

The fruit is typically a capsule, characteristic of the Euphorbiaceae family. Upon maturity, it splits open to release seeds.

- Seeds are small, hard, and black in color
- The fruit resembles that of other *Jatropha* species
- Seeds play a role in natural propagation

The reproductive morphology aligns with the general pattern seen in the genus[16].

3.7 Seedlings

Seedlings are small and delicate initially, with:

- Oval-shaped young leaves
- A reddish-brown young stem

As they grow, they gradually develop the characteristic caudex and branching pattern seen in mature plants[17].

4. TRADITIONAL USES AND ETHNOMEDICAL IMPORTANCE

- In traditional medicine, various *Jatropha* species have been used for the treatment of skin disorders, inflammation, wounds, and gastrointestinal ailments.
- Although specific ethnomedical records on *Jatropha maheshwarii* are limited, related species such as *Jatropha curcas* and *Jatropha gossypiifolia* have been widely employed as anti-inflammatory, antimicrobial, and wound-healing agents.
- These traditional claims provide a pharmacological rationale for exploring antifibrotic activity in *Jatropha maheshwarii*[18].

5. PHYTOCHEMICAL CONSTITUENTS WITH STRUCTURES

- Phytochemical investigations of the genus *Jatropha* have revealed the presence of diterpenoids, flavonoids, lignans, alkaloids, and phenolic acids.
- Major bioactive classes include phorbol esters, jatrophone, curcin, and various flavonoids such as quercetin and kaempferol derivatives.
- These compounds are known to modulate inflammatory and profibrotic signaling pathways[19].

5.1 Phytochemical Profile of the Genus Jatropha

Phytochemical investigations conducted on various species of the genus *Jatropha* (Family: Euphorbiaceae) have demonstrated the presence of a diverse range of secondary metabolites, including diterpenoids, flavonoids, lignans, alkaloids, cyclic peptides, coumarins, phenolic acids, and terpenoids. Among these, diterpenoids represent the most characteristic and extensively studied class of compounds in the genus. More than 140 diterpenoids have been identified from different *Jatropha* species, highlighting the genus as an important source of structurally unique bioactive molecules.

Comprehensive phytochemical reviews have reported that major constituents of *Jatropha* species include:

- Diterpenoids (jatrophone, curcusones, jatropholones, phorbol esters)
- Flavonoids (quercetin, kaempferol and their glycosides)
- Lignans and neolignans
- Alkaloids
- Phenolic acids
- Cyclic peptides such as curcin-related proteins
- Coumarins and coumarinolignoids

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5.2 Major Bioactive Compounds and Their Pharmacological Relevance

5.2.1 Phorbol Esters

Phorbol esters are tetracyclic diterpenoids predominantly found in the seeds and seed oil of *Jatropha curcas*. They are considered characteristic chemotaxonomic markers of the genus. These compounds interact with protein kinase C (PKC) signaling pathways and exhibit potent biological activities, including modulation of inflammation, cell proliferation, apoptosis, and fibrosis-related cellular responses. However, they are also responsible for much of the toxicity associated with *Jatropha* seeds.

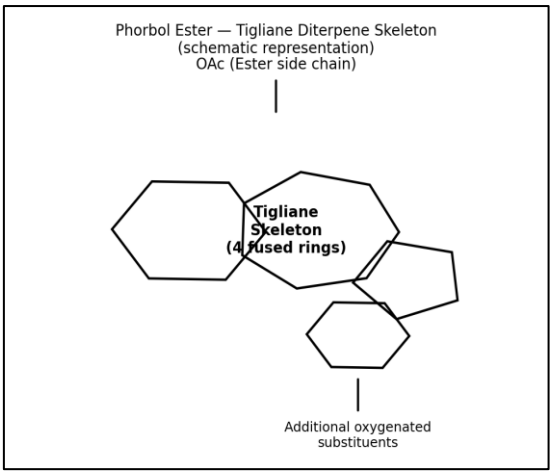


Figure 12. Representative structure of a phorbol ester (tigliane diterpenoid skeleton)

5.2.2 Jatrophone

Jatrophone is a macrocyclic diterpene originally isolated from several *Jatropha* species. It possesses notable anti-inflammatory, cytotoxic, antiproliferative, and antitumor activities. Studies suggest that jatrophone can inhibit pathways involved in fibroblast proliferation and extracellular matrix deposition, making it a potential lead compound for antifibrotic drug development[20].

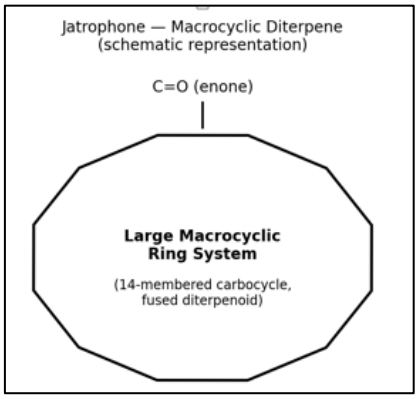


Figure 13. Structure type of jatrophone (macrocyclic diterpene)

5.2.3 Curcin

Curcin is a type I ribosome-inactivating protein isolated mainly from *Jatropha curcas* seeds. It exhibits immunomodulatory, anticancer, and anti-inflammatory activities. Curcin inhibits protein synthesis through depurination of rRNA and may contribute indirectly to antifibrotic effects by reducing inflammatory mediators involved in fibrogenesis.

- Single-chain ribosome-inactivating protein
- Molecular weight approximately 28–30 kDa

- Proteinaceous toxin rather than a small phytochemical molecule[21]

5.2.4 Quercetin

Quercetin is a flavonol widely distributed in *Jatropha* leaves and aerial parts. It exhibits strong antioxidant and anti-inflammatory activities through scavenging reactive oxygen species (ROS), inhibition of NF-κB signaling, and suppression of TGF-β-mediated fibrogenesis. These mechanisms are directly relevant to antifibrotic activity.

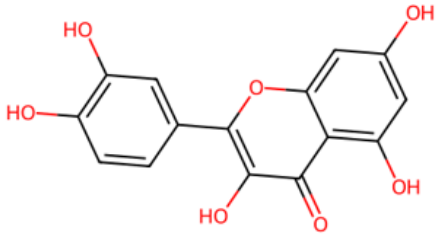


Figure 14. Chemical structure of quercetin (C15H10O7); IUPAC name: 3,3′,4′,5,7-pentahydroxyflavone

5.2.5 Kaempferol

Kaempferol is another important flavonol isolated from *Jatropha* species. It possesses antioxidant, anti-inflammatory, and antifibrotic activities. Kaempferol suppresses activation of hepatic stellate cells and reduces collagen deposition through inhibition of TGF-β/Smad signaling pathways[22].

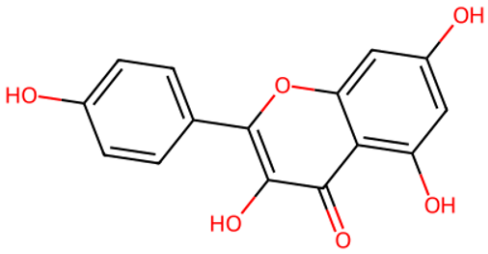


Figure 15. Chemical structure of kaempferol (C15H10O6); IUPAC name: 3,4′,5,7-tetrahydroxyflavone

5.3 Relationship with Antifibrotic Activity

Table 2. Phytochemical classes of Jatropha maheshwarii and their major mechanisms relevant to antifibrotic activity[23]

Phytochemical Class	Representative Compounds	Major Mechanisms Relevant to Antifibrotic Activity
Flavonoids	Quercetin, Kaempferol, Apigenin	Scavenge reactive oxygen species (ROS), inhibit TGF-β/Smad signalling, suppress fibroblast proliferation, reduce collagen deposition.
Phenolic compounds	Gallic acid, Caffeic acid, Chlorogenic acid	Potent antioxidant activity, reduce oxidative stress, inhibit inflammatory cytokines (TNF-α, IL-6), prevent extracellular matrix (ECM) accumulation.
Terpenoids (Diterpenes & Triterpenes)	Jatrophone, Jatropholones, β-Amyrin	Modulate inflammatory pathways, inhibit activation of hepatic and dermal fibroblasts, reduce collagen synthesis and fibrosis progression.
Saponins	Triterpenoid saponins	Exhibit anti-inflammatory and antioxidant effects, suppress fibroblast activation, decrease collagen accumulation.
Alkaloids	Various minor alkaloids	Reduce inflammatory mediator release, protect tissues from oxidative injury, indirectly limit fibrosis.
Tannins	Hydrolysable and condensed tannins	Antioxidant and free radical scavenging activity, inhibit collagen cross-linking, reduce tissue remodelling.

Sterols	β-Sitosterol, Stigmasterol	Downregulate pro-inflammatory cytokines, inhibit fibroblast proliferation, promote tissue repair.
Glycosides	Various phenolic glycosides	Antioxidant and cytoprotective effects, modulate inflammatory signalling involved in fibrosis.
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6. IN VITRO ANTIFIBROTIC ACTIVITY[24]

- In vitro studies investigating the antifibrotic activity of *Jatropha maheshwarii* have primarily utilized cultured fibroblasts and hepatic stellate cell models.

- Extracts and isolated compounds were shown to inhibit TGF-β–induced collagen synthesis, reduce α-smooth muscle actin (α-SMA) expression, and suppress fibroblast proliferation.

- Comparative analysis of available studies indicates a dose-dependent reduction in extracellular matrix accumulation, suggesting direct interference with profibrotic signaling pathways such as Smad and MAPK.

7. PHARMACOGNOSTIC EVALUATION AND PRELIMINARY PHYTOCHEMICAL SCREENING OF JATROPHA MAHESHWARII[25,26,27].

Table 3. Determination of Ash Values and Moisture Content of Jatropha maheshwarii Leaf and Stem Samples

Parameter	Leaf Sample (% w/w)	Stem Sample (% w/w)
Total ash value	8.2	9.8
Acid-insoluble ash	3.7	4.1
Acid-soluble ash	5.7	4.8
Water-insoluble ash	2.8	3.2
Water-soluble ash	3.5	4.3
Moisture content (%)	4.7	3.8

Table 4. Extractive Values of Jatropha maheshwarii Leaf and Stem Samples in Different Solvents

Solvent	Leaf Sample (% w/w)	Stem Sample (% w/w)
Petroleum ether	2.8	2.4
Benzene	3.4	3.8
Chloroform	2.8	3.1
Methanol	6.1	5.2
Water	10.5	8.8

Table 5. Fluorescence Analysis of Jatropha maheshwarii Leaf and Stem Powder

Sample	Leaf Powder (Visible Light)	Leaf Powder (UV 365 nm)	Stem Powder (Visible Light)	Stem Powder (UV 365 nm)
Powder	Greenish brown	Dark green	Light green	Dark brown
Powder + Water	Brown	Dark green	Light brown	Dark brown
Powder + HCl	Light green	Greenish	Dark brown	Brown
Powder + Conc. H_2SO_4	Brown	Dark brown	Reddish brown	Black
Powder + Conc. HNO_3	Brown	Black	Yellowish brown	Yellowish green
Powder + NaOH	Black	Greenish black	Light green	Brown
Powder + Methanol	Light green	Dark green	Yellow	Greenish yellow
Powder + NHCl	Black	Dark green	Green	Brown
Powder + O.NHCl	Light green	Dark green	Brown	Brown

Table 6. Preliminary Phytochemical Screening of Methanolic Extracts of Jatropha maheshwarii Leaf and Stem

Phytoconstituent	Leaf Extract	Stem Extract
Alkaloids	+++	++
Tannins	+++	+
Flavonoids	++	+
Steroids	+	+
Glycosides	+	++
Saponins	++	+
Coumarins	+	+

+ = Present

++ = Moderately present

+++ = Abundantly present

8. FUTURE PERSPECTIVE OF IN VIVO STUDIES

- While in vitro findings are promising, in vivo validation is essential to establish the therapeutic relevance of *Jatropha maheshwarii*.

- Future studies should focus on well-characterized animal models of liver, lung, and renal fibrosis to evaluate efficacy, pharmacokinetics, and safety.

- Standardization of extracts, identification of lead compounds, and mechanistic studies at the molecular level will be critical for advancing *Jatropha maheshwarii* toward clinical application[28].

8.1 Discussion

The available literature suggests that phytochemicals reported from Jatropha species, particularly flavonoids, diterpenoids and phenolic compounds, may modulate oxidative stress, TGF-β/Smad signalling and extracellular matrix deposition. However, evidence specific to Jatropha maheshwariii remains limited, and well-designed in vitro and in vivo studies are required before clinical translation.

9. CONCLUSION

Jatropha maheshwarii represents a potential source of novel antifibrotic agents based on its phytochemical richness and preliminary in vitro evidence.

Integration of traditional knowledge with modern pharmacological evaluation may facilitate the development of plant-based antifibrotic therapeutics. However, comprehensive in vivo and clinical studies are required before therapeutic translation can be achieved[29].

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Conflict of Interest Statement: All authors have nothing else to disclose.

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