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# RECENT DEVELOPMENTS IN *JATROPHA CURCAS* L.: PHYTOCHEMISTRY, AND PHARMACOLOGY APPLICATIONS

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**Keywords:**

*Jatropha curcas*, Phytochemistry, Pharmacological activities, Medicinal plant, Wound healing

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**ABSTRACT:** *Jatropha curcas* L., a member of the Euphorbiaceae family, is a multipurpose medicinal plant widely distributed in tropical and subtropical regions. It possesses diverse phytochemicals such as flavonoids, alkaloids, diterpenoids, and phenolics, which contribute to its broad pharmacological profile. Traditional uses and experimental studies highlight its therapeutic potential, including anti-inflammatory, antimicrobial, antiviral, anticancer, antidiabetic, anti-arthritic, wound healing, and hepatoprotective activities. Various plant parts such as leaves, bark, seeds, latex, and roots have demonstrated significant biological effects in both *in-vitro* and *in-vivo* models. Additionally, the plant exhibits enzymatic activities and industrial applications, particularly in biofuel production and biocatalysis. Despite its medicinal benefits, toxicity at higher doses necessitates careful evaluation. Overall, *J. curcas* represents a promising natural resource for drug development and sustainable applications, warranting further pharmacological and clinical investigations.

**INTRODUCTION:** For thousands of years, people have employed natural goods, particularly plants, to heal a variety of illnesses [1]. With around 7,800 species spread across about 300 genera and five subfamilies globally, the Euphorbiaceae family is one of the biggest angiosperm families. Tropical and subtropical areas are home to the majority of these species. One of its significant genera is *Jatropha* L., which has over 200 species and is a member of the tribe Jatropheae and subfamily Crotonoideae. The genus is found throughout the Americas and Africa [2].

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The Greek words "jatros" (doctor) and "trophe" (meal) are the basis of the word "Jatropha," which reflects its ancient medical importance. Jatropha and Curcas are the two subgenera that make up the genus; the former is more widely distributed over Africa, India, South America, Central America, the West Indies, and the Caribbean. In addition to being utilised as decorative plants and bioenergy crops, several *Jatropha* species are employed in traditional medicine to cure a variety of illnesses [3, 4].

*Jatropha curcas*, *Jatropha gossypiifolia*, and *Jatropha elliptica* are notable species. Because of its exceptional flexibility and endurance, *Jatropha curcas*, a woody shrub of the Euphorbiaceae family, is regarded as the most extensively dispersed species among the many species of the genus Jatropha.

**Taxonomy:**

- Kingdom: Plantae
- Division: Angiosperms
- Class: Eudicots
- Order: Malpighiales
- Family: Euphorbiaceae
- Genus: Jatropha
- Species: *Jatropha curcas* L. [5]

The genus belongs to the tribe Joannesieae and includes shrubs, trees, and herbs.

**Vernacular Names:** Common names of *Jatropha curcas* include:

- Physic nut – widely used in English-speaking countries
- Goat nut – common in some rural regions
- Pinhão-manso – Brazil
- Barbados nut – Caribbean regions
- Purging nut – refers to its traditional laxative use
- Nettle spurge – descriptive of its milky sap
- Ratanjyot – India (Hindi)
- Bagbherenda – India (regional) [5]

**Habitat:** Because of its extreme resilience and ability to flourish in tropical and subtropical climates, *Jatropha curcas* is best suited to areas with warm temperatures and seasonal rainfall.

It is well suited to dry and semi-arid regions, where many other crops would fail due to restricted water supply. On areas with low nutrient content, high salinity, or little organic matter, the plant may thrive on poor, marginal, and degraded soils [6]. It is a perfect choice for cultivation on wastelands and damaged fields because of its hardiness, which enables it to endure extended dry spells and thrive in difficult soil conditions. In addition to ensuring its survival in less fertile locations, its flexibility offers chances for soil conservation, erosion control, and sustainable land management in areas where traditional agriculture is challenging. *Jatropha curcas* has considerable ecological and economic potential due to its ability to withstand harsh environmental circumstances. This is particularly true when it comes to encouraging reforestation, preventing desertification, and boosting the production of biofuel in regions that are not appropriate for food crops [7].

**Geographical Distribution:** *Jatropha curcas* is said to have started in Central America and spread to other areas as a result of human activity. According to historical records, Portuguese seamen were crucial in the plant's spread, transporting it from the Caribbean islands to many African and Asian nations *via* the Cape Verde Islands and the former Portuguese Guinea (now Guinea-Bissau) [5, 7]. Over time, it was able to effectively establish itself in tropical and subtropical locations all over the world thanks to its flexibility and tenacity. Due to its deterring qualities, which prevent cattle from grazing it, *Jatropha curcas* is now commonly grown in these areas and frequently utilised as a protective hedge around gardens, farms, and fields. Its extensive cultivation is a reflection of both its usefulness in agricultural systems and its ability to flourish in a variety of environmental circumstances. As a result, in many tropical and subtropical nations, *Jatropha curcas* has grown to be a significant multifunctional plant with ecological, economic, and protective value [8].

**Botanical Description:** It is a little tree or shrub with smooth grey bark that, when cut, releases watery, white latex. It typically reaches a height of three to five meters, but in ideal circumstances, it may reach eight or ten meters [9].

**FIG. 1: LEAVES, STEM FLOWERS AND FRUITS OF *JATROPHA CURCAS***

**TABLE 1: BOTANICAL DESCRIPTION OF *JATROPHA CURCAS* [10, 11]**

| Plant Part | Description |
|---|---|
| Leaves | Large, green to pale-green; alternate to sub-opposite; 3–5 lobed; spiral phyllotaxis. |
| Flowers | Petiole length: 6–23 mm; inflorescence formed in leaf axil; flowers formed terminally and individually. Female flowers are slightly larger and occur mainly in hot seasons. Continuous growth may cause unbalanced pistillate/staminate flower production, increasing female flower numbers. Bee-keeping enhances female flower production, leading to more seeds. |
| Fruits | Produced in winter when shrub is leafless, or multiple crops if soil moisture and temperature are adequate. Each inflorescence yields ~10 ovoid fruits. Fruits form 3 bi-valved cocci after seed maturation and drying of fleshy exocarp. |
| Seeds | Mature when capsule changes from green to yellow, 2–4 months post-fertilization. Seeds are blackish, thin-shelled, oblong, resembling small castor seeds. |

**Ethnomedical Uses [12]:** *Jatropha curcas* has extensive traditional uses:

**Internal uses:**

- Treatment of diarrhea, dysentery, and digestive disorders
- Used as a purgative (seed oil)
- Management of malaria, fever, and anemia

**External uses:**

- Latex applied for wound healing and infections
- Used for skin diseases, ulcers, and inflammation
- Treatment of rheumatic and muscular pain

**Other uses:**

- Root extracts used as antidote for snake bites
- Antimicrobial use against bacteria like *Staphylococcus aureus*

The plant is used in treating nearly 100 different ailments in traditional medicine systems.

**TABLE 2: ETHNOMEDICAL USES [13, 14, 15, 16]**

| Plant Part / Extract | Ethnomedicinal Uses / Application |
|---|---|
| Whole plant / general | Abortifacient, anodyne, antiseptic, diuretic, emetic, hemostat, lactagogue, narcotic, purgative, rubefacient, styptic, vulnerary |
| Physic nut | Alopecia, ascites, burns, convulsions, cough, dermatitis, diarrhea, dropsy, dysentery, dyspepsia, eczema, fever, gonorrhea, hernia, incontinence, inflammation, jaundice, neuralgia, paralysis, parturition, pneumonia, rash, rheumatism, scabies, sciatica, sores, stomachache, syphilis, tetanus, thrush, tumors, ulcers, uterosis, yellow fever |
| Latex | Topical for bee/wasp stings, sores, ulcers, inflamed tongue, toothache, burns, hemorrhoids, ringworm, ulcers |
| Leaf decoction | Arthritis, Venereal disease |
| Heated leaves | Lactagogue |
| Root decoction | Dysentery and Mouthwash for bleeding gums |
| Seeds | Dropsy, gout, paralysis, skin ailments |
| Leaves | Antiparasitic (scabies), rubefacient (paralysis, rheumatism), applied to hard tumors |
| Seed oil | Emetic, laxative, purgative, skin ailments |
| Massage oil (from plant) | Massage ascitic limbs |

**Phytochemistry:** The therapeutic potential and toxicity of *Jatropha curcas* are supported by a wide range of bioactive substances. Alkaloids like curcin and jatrophine are prominent among the principal phytoconstituents because of their biological activity, which includes cytotoxic and antibacterial properties [17, 18]. Phenolics and lignans offer extra antioxidant, antibacterial, and anti-inflammatory properties, while flavonoids such as apigenin, vitexin, and isovitexin contribute to its cardioprotective and antioxidant benefits. Fatty acids and sterols, which have pharmacological and nutritional value, are also present in *Jatropha curcas* [19, 20]. The plant also contains glycosides, coumarins, and cyclic peptides, all of which contribute to its pharmacological variety. Together, these substances explain the plant's many therapeutic uses in conventional medicine, including the treatment of infections, inflammation, and digestive issues.

They also explain the plant's possible toxicity, especially in seeds and latex, which calls for cautious use in medicinal preparations [21, 22, 23].

**Pharmacological Activity:**

**Anti-Inflammatory and Analgesic Potential:** Several studies investigated the anti-inflammatory and analgesic potential of *Jatropha curcas* L. Mujumdar *et al.* (2004) demonstrated that topical application of root powder in paste form reduced TPA-induced ear inflammation in albino mice. Methanol extracts of the roots showed systemic anti-inflammatory activity in acute carrageenan-induced rat paw edema, formalin-induced edema, turpentine-induced exudative changes, and cotton pellet-induced granuloma formation after oral treatment for seven days.

These effects were attributed to modulation of inflammatory mediators, arachidonic acid metabolism via the cyclo-oxygenase pathway, reduced prostaglandin formation, inhibition of leukocyte migration, and anti-proliferative activity [24]. Similarly, Dasgupta *et al.* (2019) evaluated methanolic extracts of *J. curcas* fruits and found significant analgesic and anti-inflammatory activity in hot plate and carrageenan-induced paw edema models, comparable to standard drugs diclofenac and aspirin [25].

Othman *et al.* (2019) examined different plant parts and identified roots as the most potent anti-inflammatory source. Methanolic extracts were fractionated, with the hexane fraction showing the highest activity. Chromatographic separation and GC-MS, LC-MS/MS, and NMR analyses revealed bioactive long-chain fatty acids, including hexadecanoic acid methyl ester, octadecanoic acid methyl ester, oxooctadecanoic acids, and dihydroxyoctadecadienoic acids, which inhibited nitric oxide production in RAW 264.7 macrophage cells without cytotoxicity [26]. Arif *et al.* (2020) reviewed both *in-vitro* and *in-vivo* studies and confirmed that *J. curcas* reduced edema, limited neutrophil infiltration, and modulated key inflammatory mediators, supporting its traditional use in treating inflammation, fever, and wound healing. Collectively, these studies highlighted *J. curcas* as a promising natural source of anti-inflammatory compounds with potential therapeutic relevance [27].

**Antimicrobial Activity:** Ahmed *et al.* (1979) reported that *Jatropha curcas* seeds were toxic to calves at doses ranging from 0.025 to 2.5 g/kg, with clinical signs including diarrhea, dyspnea, dehydration, and loss of condition, leading to death within hours to days depending on the dose. Biochemical analysis showed increased serum aspartate aminotransferase, ammonia, and potassium, along with decreased total protein and calcium. Despite its toxicity in animals, several studies highlighted the plant's potent antimicrobial and pesticidal properties [28]. Fagbenro-Beyioku *et al.* (1998) observed that sap and crushed leaves of *J. curcas* exhibited germicidal activity against bacteria such as *Staphylococcus*, *Bacillus*, and *Micrococcus*, and effectively inhibited the embryonation and hatchability of Ascaris lumbricoides and hookworm larvae. The sap also impaired mosquito larval development, suggesting potential use as a low-cost disinfectant and malaria vector control agent [29].

The pesticidal activity of *J. curcas* seeds was further demonstrated by Adedire and colleagues (2003), who showed that seed oil reduced oviposition and protected cowpea seeds from *Callosobruchus maculatus* for up to 12 weeks [30]. Saosoong and Ruangviriyachai (2016) reported that methanolic fruit extracts inhibited several plant pathogenic bacteria, with GC–MS analysis indicating flavonoid compounds as the active bioagents [31]. Recent studies focused on oral and human pathogens. Kamaruddin *et al.* (2024) found that ethanolic leaf extracts and stem bark latex of *J. curcas* inhibited *Streptococcus* species and *Candida* spp., with bioactive compounds including isovitexin, 2-hexyl-decanoic acid, and trihydroxybenzoic acid [32]. Abdulsalam *et al.* (2025) showed that *J. curcas* sap inhibited *Staphylococcus aureus* growth in a concentration-dependent manner, with higher concentrations producing larger inhibition zones. Collectively, these studies highlighted *J. curcas* as a valuable natural source of antimicrobial, antifungal, and pesticidal agents, although its toxicity in higher doses warrants careful handling and application [33].

**Anticancer Effect:** Lin *et al.* (2003) investigated the antitumor activity of curcin, a ribosome-inactivating protein isolated from *Jatropha curcas*, using MTT assays and a cell-free rabbit reticulocyte lysate system [34]. Curcin exhibited potent inhibitory activity on protein synthesis with an $IC_{50}$ of 0.19 nmol/L and effectively suppressed the growth of several cancer cell lines, including SGC-7901, Sp2/0, and human hepatoma cells, while showing no toxicity toward HeLa and normal MRC cells. These findings suggested that curcin selectively targeted tumor cells without harming normal tissues, highlighting its potential as a therapeutic agent.

Muangman *et al.* (2005) explored the antimetastatic potential of curcusone B, a diterpene from *J. curcas*, against four human cancer cell lines. Non-cytotoxic doses of curcusone B significantly reduced *in-vitro* invasion, motility, and matrix metalloproteinase secretion, although its effect on adhesion to Matrigel varied. The study concluded that curcusone B could suppress metastatic processes without inducing cytotoxicity, offering promise for controlling cancer metastasis [35]. Similarly, Aiyelaagbe *et al.* (2011) reported that root extracts and isolated diterpenoids from *J. curcas* exhibited strong cytotoxic activity against L5178y mouse lymphoma and HeLa cells, while showing minimal neurotoxicity toward PC12 cells, supporting the potential of these compounds as anticancer agents with low off-target effects [36]. Asep *et al.* (2017) evaluated the cytotoxicity of jatrophone, isolated from *Jatropha gossypifolia*, against multiple human cancer cell lines, including HepG2 (liver), WiDr (colon), HeLa (cervix), and AGS (stomach). Jatrophone displayed the highest potency against HepG2 cells ($IC_{50}$ = 3.2 µM), exceeding the anticancer activity of standard drugs such as sorafenib and arsenic trioxide. These results suggested that jatrophone could serve as a promising lead compound for hepatocellular carcinoma treatment, demonstrating selective cytotoxicity across different tumor types [37].

Saleh *et al.* (2023) investigated methanol leaf extracts from *J. curcas*, *J. gossypifolia*, and *J. multifidia* for anticancer and antimicrobial activity. Phytochemical analysis revealed flavonoids, tannins, alkaloids, saponins, terpenes, and sterols in the extracts. The *J. curcas* extract showed strong activity against HepG2 cells (selective index 2.04) and antimicrobial effects against Gram-positive and Gram-negative bacteria. Fractionation and GC-MS analysis identified bioactive compounds such as hexadecanoic acid, anethole, oleic acid, and carvacrol, suggesting that these metabolites contribute to both anticancer and antimicrobial effects. Collectively, these studies highlighted the potential of *Jatropha* species as sources of bioactive compounds with anticancer, antimetastatic, and selective cytotoxic activities [38].

**Anticoagulant and Proteolytic Properties:** Osoniyi *et al.* (2003) investigated the coagulant and anticoagulant activities of *Jatropha curcas* latex, traditionally used as a haemostatic. The study showed that whole latex significantly reduced human blood clotting time, while diluted latex prolonged clotting, with high dilutions preventing clot formation entirely. Prothrombin time (PT) and activated partial thromboplastin time (APTT) tests confirmed these dual activities. Solvent partitioning partially separated the opposing effects: the ethyl acetate fraction exhibited procoagulant activity at low concentrations, whereas the butanol fraction showed strong anticoagulant activity. The residual aqueous fraction had minimal effect on clotting time and PT but slightly prolonged APTT, demonstrating that *J. curcas* latex contains distinct components influencing blood coagulation differently [39].

Gubbiveeranna *et al.* (2019) further characterized the anticoagulant and proteolytic properties of *J. curcas* latex, showing that it contained bioactive proteases capable of degrading fibrinogen and collagen and interfering with the coagulation cascade. These findings supported the traditional use of the latex in wound management and suggested its potential as a natural antithrombotic agent for treating coagulation-related disorders. Collectively, these studies highlighted that *J. curcas* latex possesses both procoagulant and anticoagulant activities, with promising therapeutic implications for hemostasis and thrombosis management [40].

**Anti-diabetic Activity:** Mishra *et al.* (2010) evaluated the antihyperglycemic activity of a 50% ethanolic leaf extract of *Jatropha curcas* in alloxan-induced diabetic rats. Oral administration at doses of 250 and 500 mg/kg body weight produced a significant reduction in blood glucose levels, comparable to the standard drug glibenclamide.

The extract also showed a high safety margin, with an $LD_{50}$ of 2500 mg/kg as per OECD guidelines [41]. Similarly, Kumar *et al.* (2016) assessed the antidiabetic activity of hydroethanolic leaf extract in alloxan-induced diabetic rats and reported a significant decrease in blood glucose levels in treated groups compared to diabetic controls. The treatment also improved hematological parameters, increased serum protein and albumin levels, and reduced elevated serum creatinine, urea, cholesterol, and enzyme levels. Additionally, oxidative stress markers such as lipid peroxidation were reduced, while glutathione levels increased, indicating antioxidant potential [42].

Asuk (2018) further investigated the effects of ethanol-methanol extracts of leaf, stem bark, and root of *J. curcas* on liver function markers in streptozotocin-induced diabetic rats. The study demonstrated significant improvement in liver enzyme levels and restoration of protein balance, suggesting protection against diabetes-induced hepatic damage. Among the plant parts, the leaf extract exhibited the most pronounced hepatoprotective effect. Collectively, these studies indicated that *Jatropha curcas* possesses significant antidiabetic, antioxidant, and hepatoprotective properties, supporting its potential use in managing diabetes mellitus and its associated complications [43].

**Toxicity Study:** Nwaka *et al.* (2015) investigated the effects of ethanol extracts of *Jatropha curcas* on hematological parameters in chloroform-intoxicated rats. The study evaluated indices such as white blood cell count, hemoglobin level, and packed cell volume, and reported significant improvements in these parameters following treatment. However, no notable effect was observed on red blood cell count. The findings suggested that the extract exerted a protective effect against toxin-induced hematological alterations. Acute toxicity assessment further indicated that the extract was relatively safe at lower doses, supporting its potential therapeutic application in managing chemically induced toxicity [44].

Sawadogo *et al*. (2018) assessed the acute and subacute toxicity of aqueous leaf extracts of *J. curcas* using experimental animal models. The study involved hematological, biochemical, and histological evaluations following short- and medium-term administration. The results demonstrated that the extract exhibited low overall toxicity, although higher doses caused moderate adverse effects, including alterations in blood parameters and mild histopathological changes in the liver and kidneys. Additionally, some protective effects on cardiovascular parameters were observed. Collectively, these studies suggested that Jatropha curcas extracts are relatively safe at lower doses but require careful dose optimization to avoid potential toxic effects at higher concentrations [45].

**Hepatoprotective Study:** Dangambo *et al.* (2015) evaluated the acute toxicity and hepatocurative potential of aqueous leaf extract of *Jatropha curcas* in rats with chemically induced liver injury. The extract was found to be relatively safe and demonstrated significant hepatoprotective effects by improving biochemical markers and restoring normal physiological conditions. Its therapeutic efficacy was comparable to that of a standard hepatoprotective drug, suggesting its potential usefulness in managing liver disorders [46]. Ale *et al.* (2022) examined the effects of oral administration of ethanolic and aqueous root extracts of *J. curcas* on liver function in adult female rats. Biochemical analysis revealed that ethanolic extracts significantly reduced liver enzymes such as SGOT, SGPT, and urea levels, while some aqueous extract-treated groups showed reductions in ALP and bilirubin levels. However, none of the extracts was found to be completely safe, as certain alterations in biochemical parameters were observed, indicating the need for further investigation [47].

Mahajan *et al.* (2023) investigated the hepatoprotective activity of aqueous leaf extract against carbon tetrachloride ($CCl_4$)-induced hepatic injury in rats. Oral administration of the extract (200 mg/kg) significantly reduced serum marker enzymes such as SGOT, SGPT, ALP, and bilirubin levels and restored them toward normal values. Histopathological studies further confirmed liver protection, with effects comparable to the standard drug Liv-52. Collectively, these studies indicated that *Jatropha curcas* possesses significant hepatoprotective potential, although careful dose optimization and extended studies are required to ensure its safety and therapeutic efficacy [48].

**Antiviral Potential:** Patil *et al.* (2013) investigated the antiviral potential of *Jatropha curcas* leaf extracts against Influenza A (H1N1), demonstrating that both aqueous and methanolic extracts contain bioactive compounds such as flavonoids, saponins, and tannins. These extracts were found to be non-toxic at lower concentrations and exhibited significant antiviral activity by inhibiting the viral hemagglutinin protein, thereby preventing virus adsorption. The findings highlight the potential of *J. curcas* as a natural source of anti-influenza agents and support further research into its development as a plant-based antiviral therapy [49].

In another study, Babu *et al*. (2021) explored the anti-aggressive effects of aqueous seed extract of *Jatropha curcas* using a foot shock-induced aggression model. The extract, administered orally at doses of 100 and 250 mg/kg, showed mild anti-aggressive activity comparable to diazepam, a standard anxiolytic drug. The observed effects are likely linked to the modulation of neurotransmitters such as serotonin (5-HT), gamma-aminobutyric acid (GABA), and dopamine, which play critical roles in aggression. These findings suggest that *J. curcas* may also serve as a natural therapeutic agent for managing aggression with minimal sedative side effects [50].

**Anti-arthritis activity:** Baroroh HN *et al.* (2014) demonstrated the anti-arthritic potential of *Jatropha curcas* leaf ethanolic extract using an adjuvant-induced arthritis (AIA) model in male Wistar rats. The extract, administered at doses of 150, 300, and 600 mg/kg, significantly reduced arthritis scores and improved mobility compared to the control group. Histopathological analysis further confirmed its therapeutic effect, showing reduced edema and protection against cartilage destruction in arthritic joints [51]. Similarly, See GLL *et al.* (2017) evaluated the anti-arthritic activity of *J. curcas* leaf extract in collagen type II-induced arthritis in male albino mice. The study revealed a dose-dependent reduction in paw thickness and improvement in histopathological parameters such as inflammatory cell infiltration, cartilage damage, and bone erosion. The extract exhibited significant efficacy compared to controls, with a calculated median effective dose (ED50) of 963.86 mg/kg, supporting its potential as an anti-arthritic agent [52]. Further supporting these findings, Sharma H *et al.* (2023) investigated the anti-arthritic activity of *Jatropha curcas* flower extracts, particularly the ethanolic extract, in rats with Complete Freund's adjuvant-induced arthritis. Oral administration at doses of 200 and 400 mg/kg resulted in a notable reduction in paw edema and improvement in hematological parameters by day 28 of treatment. Collectively, these studies highlight that different parts of *J. curcas*, including leaves and flowers, possess significant anti-arthritic properties, likely attributed to their anti-inflammatory and antioxidant activities. These findings suggest that *J. curcas* could serve as a promising natural candidate for the development of anti-arthritic therapies, warranting further pharmacological and clinical investigations [53].

**Esterase and Lipase Activity in Seeds:** Staubmann R *et al.* (1999) investigated the enzymatic profile of *Jatropha curcas* seeds and identified two esterases (JEA and JEB) along with a lipase (JL). The study revealed that lipase activity was specifically associated with seed germination, reaching its peak after four days. All enzymes exhibited optimal activity in the alkaline range (around pH 8), while the purified esterases demonstrated notable thermal stability. Molecular characterization showed that esterase JEA had a molecular weight of 21.6–23.5 kDa and an isoelectric point of 5.7–6.1, whereas esterase JEB had a molecular weight of 30.2 kDa with an isoelectric point of 9.0. Both esterases were capable of hydrolyzing short-chain substrates such as tributyrin, nitrophenyl esters (up to C4), and naphthyl esters (up to C6), although their activity was negatively affected by most ions [54]. Additionally, the lipase (JL) exhibited distinct catalytic properties depending on water activity. It showed maximum efficiency in transesterification reactions at very low water activity (0.2), while at higher water levels it effectively hydrolyzed triglycerides, achieving conversion rates above 80%. These findings suggest that the lipase from *J. curcas* seeds has strong potential as a biocatalyst, particularly in the hydrolysis of triglycerides in organic solvent systems, highlighting its possible industrial and biotechnological applications.

**Wound Healing Activities:** Shetty S *et al.* (2005) demonstrated that *Jatropha curcas* bark extract significantly enhances wound healing in albino rats by improving multiple healing parameters, including skin breaking strength, granulation tissue strength, wound contraction, dry granulation tissue weight, and hydroxyproline content, which reflects increased collagen synthesis. The study also reported a reduced epithelization period, indicating faster wound closure. Histopathological analysis revealed a more advanced healing phase, characterized by dense and well-organized collagen fiber bundles [55]. Similarly, Sachdeva K (2011) provided further scientific validation of the wound healing potential of *J. curcas* stem bark extract using excision and incision wound models in rats. Treatment with 5% and 10% extract ointments significantly improved wound contraction, tensile strength, hydroxyproline levels, and histopathological features compared to the control group, with results comparable to the standard drug silver sulfadiazine [56].

More recently, M. Nur Salim *et al.* (2021) investigated the efficacy of *Jatropha curcas* sap cream in treating infected wounds in mice induced with *Staphylococcus aureus*. The study demonstrated that 10% *Jatropha* sap cream significantly enhanced wound healing compared to the base cream and showed effects comparable to sulfadiazine treatment. Macroscopic and histopathological observations indicated reduced wound length, improved inflammatory response, and enhanced neovascularization during the early healing phase. A significant decrease in inflammatory cell infiltration and improved tissue regeneration were also noted. Collectively, these studies confirm that various parts of *J. curcas*, including bark and sap, possess strong wound healing properties, likely due to their ability to promote collagen formation, reduce inflammation, and accelerate tissue repair, supporting their potential use as natural topical therapeutic agents [57].

**Anti-stress Activity:** Mohamed *et al.,* (2020) investigated the response mechanisms of *Jatropha curcas* seedlings under lead (Pb) stress. The study evaluated Pb accumulation, metabolite contents, antioxidant activity, and the levels of phenolics and flavonoids. Gene expression analysis focused on metallothionein (JcMT2a) and phenylalanine ammonia-lyase (JcPAL), which are involved in metal detoxification. Seedlings exhibited differential accumulation of Pb in roots, stems, and leaves and showed activation of antioxidant defense systems in response to metal stress. Enhanced phenolic and flavonoid levels were associated with increased total antioxidant capacity and radical scavenging activity. The study demonstrated that upregulation of JcPAL and related antioxidant responses played a central role in Pb tolerance, providing biochemical and genetic insights into the plant's metal detoxification mechanisms [58].

**Anti-diarrhoeal Activity:** Mujumdar AM et al., 2001Antidiarrhoeal activity of root extract Use of *Jatropha* roots in the treatment of diarrhoea is a common ethnobotanical practice in Konkan, a part of the Western coastal area of India. Roots of this species were undertaken for pharmacognostic studies and evaluation of antidiarrhoeal activity in albino mice. The methanol fraction after successive extraction showed activity against castor oil induced diarrhoea and intraluminal accumulation of fluid. It also reduced gastrointestinal motility after charcoal meal administration in albino mice. The results indicate that action of *J. curcus* root methanol extract could be through a combination of inhibition of elevated prostaglandin biosynthesis and reduced propulsive movement of the small intestine [59].

**CONCLUSION:** *Jatropha curcas* is a versatile plant with significant medicinal, ecological, and industrial importance. Extensive studies confirm its wide range of pharmacological activities, including anti-inflammatory, antimicrobial, antidiabetic, anticancer, and wound healing effects, largely attributed to its rich phytochemical composition. Its adaptability to harsh environmental conditions and potential in biofuel production further enhance its value. However, the presence of toxic constituents, especially in seeds and latex, emphasizes the need for controlled usage and dose optimization. Future research should focus on isolating active compounds, understanding mechanisms of action, and conducting clinical trials to ensure safety and efficacy. With proper scientific validation, *J. curcas* holds strong potential as a source of novel therapeutic agents and sustainable bioproducts.

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