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A REVIEW ON THE MEDICINAL USES AND TOXICOLOGICAL EFFECTS OF HERBAL PLANT JATROPHA CURCAS L

Sarabia, James Brian F., Calalas, Alan Grant S., Gregorio, Justine P., Maceren, Jeby Isabel G., Padayhag, Wayne Rose L., Faller, Erwin M.*

Pharmacy Department, San Pedro College, Davao City, Philippines

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ABSTRACT

Purpose: The goal of this review is to ascertain the therapeutic relevance of *Jatropha curcas L.*, as well as its biological and pharmacological applications in order to give current evidence based applications and risks of toxicity of the plant.

Method: Evidence based and highly relevant studies from peer reviewed papers pertaining to *Jatropha curcas L.* were thoroughly reviewed.

Results: *Jatropha curcas L.* is utilized for medicinal uses and various segments of the plant contains an oil that is semi-dry which has shown to induce functional and important therapeutic remedies. Its antimicrobial, anti-inflammatory, anti-cancer, antiviral activity are well known. Despite its medicinal properties, Jatropha plants are known for their poisonous nature. Previous studies on humans/animals have shown that it causes hepatotoxicity, cell death, diarrhea, depression, gastroenteritis, and many more and is caused by toxalbumins present in the plant.

Conclusion: *Jatropha curcas* L., is a plant with numerous purposes with a handful of potential applications in multiple areas of medicine. Various parts of the plant have pharmacological uses that have undergone extensive research and studies. Nevertheless, it's evident that further study has to be made before this plant can be established as a perennial medicinal plant due to its toxic nature.

Keywords: *Jatropha curcas, Tuba-tuba, Herbal plant, Medicinal uses, Toxicology*

1. INTRODUCTION

In these past few years, the rising incidence of microorganisms that resists treatment to multiple drugs, and new strains that have been emerging which have a lower antimicrobial susceptibility has prompted a pursuit for organic active compounds to regulate pests while lessening diseases and adverse effects generated by synthetic compounds [1]. Among the few plants that have a huge possibility to save lives is *Jatropha curcas*. The plant of focus belongs to a huge family of flowering plants, Euphorbiacea. *J. curcas L.* is domestically from the American tropics but is extensively distributed on the whole world [2]. It is often recognized as 'physic nut,' or 'purging nut' possibly a homage to its pharmacological use. It is known to be a plant that resists drought and is able to thrive in ruined soils [3].

It has been recognized for its therapeutic potential. The leaves of this plant and also its seeds, have been utilized in herbal and traditional medicine and also quite effective as a veterinary medicine. The oil has a high capacity for removing waste from the body and is successfully utilized as a remedy for skin diseases and distress triggered by rheumatism. Meanwhile a preparation made from its leaves has been well known to treat coughs and also as an antiseptic after birth. A decoction preparation made from its roots is used to treat pneumonia and syphilis, as well as as an abortion pill, and anthelmintic. Both the seeds and the fruit are often used as a form of contraception in South Sudan. Besides that, various medicines derived from the seeds are used to treat ascites, arthritis, immobility, and skin infections. The whitish colored latex acts like a disinfectant in a kid's mouth infectious diseases. Furthermore, its latex contains antineoplastic alkaloids such as curcain and Jatrophine [3]. J. curcas is shown to have antibacterial activities against organisms such as S. aureus and E. coli.

But as we view it from a different perspective, several scientific investigations have revealed that the plant has harmful adverse effects on both people and animals. The adverse effects that this plant causes includes abdominal pain, vomiting and diarrhea which were recorded to have occurred in children who consumed it. There have already been demonstrations in animal experiments that it causes distress, anxiety, bleeding, & dehydration.

In totality, this journal review aims to collate numerous substantial findings on the medical uses and toxicological effects of a herbal plant tuba-tuba from previous researches, in order to establish if the medical uses that have been claimed have solid evidence to support it and to pave the way for future studies in discovering how to neutralize its toxic effects.

2. METHODS

The literature was analyzed thoroughly utilizing a range of national and international scientific sources, including PubMed, Science Direct, Current Pharmaceutical Biotechnology, and the South African Journal of Botany. The study database includes original articles, other studies, theses and books of various aspects of the plant species that had been peer-reviewed for academic quality. There were no specific article format criteria. Therefore any relevant literature, including clinical trials, comprehensive reviews, editorials, and perspectives with topics within the scope of the study were considered.

3. DISCUSSIONS

3.1. Botanic Information of *Jatropha curcas L.*

The Jatropheae tribe of the Euphorbiaceae family includes the genus Jatropha, It has over 170 species [4]. Jatropha is the scientific name for the species which was created by combining the Greek terms"Jatros" which means "doctor" and "trophe" which means "food", including [21] the plant's ancient medical use [5]. The genus Jatropha is part of the Crotonoideae tribe Joannesieae, which is part of the Euphorbiaceae family and has over 175 species. Pax's subdivision was changed by Dehgan and Webster [6] and there are currently ten sections and 10 subsections to accommodate Old and New World species in two subgenera of the genus Jatropha (Curcas and Jatropha).They proposed *J. curcas*, a physic nut is the genus Jatropha's most primitive form. Other sections of the plant have changes in growth habits and its floral architecture; it also emerged from the physic nut or another older form.

The bark of Jatropha curcas is pale brown, papery, and peeling; the cut produces a profuse liquid latex that ranges from soapy to touch but when dried, it becomes brittle and reddish, and the branches are glabrous, ascending, and robust. *Jatropha curcas*, a diploid species consisting of 22 chromosomes [4], is also a 3–5 m dense and tall shrub or tiny tree with a maximum height of 10 meters in perfect conditions. In Mexico, genotypes are classified as hazardous or non-toxic [7].

The plant has an articulated growth pattern and may survive for up to 50 years [8]. It is a deciduous plant having a morphological break [7]. The root system is composed of four shallow lateral roots and a central taproot. Glabrous branches and there was smooth greenish-bronze bark and translucent latex. The leaves are smooth,5-lobed and heart-shaped, with a dark green base cordate or spherical, acute at the apex,cordate at the base, alternate [32], and falling once a year [6]. Axillary flower clusters with 3–5 cm stalks, whole, lanceolate or linear pubescent and yellowish-green bracts, and massive glandular discs on the blooms [2]. Male flowers feature 5 ovate-elliptic sepals that are less than 4 mm long and 5 oblong-ovate petals. 6–7 mm long, joined in the lowest portion, densely hairy inside, and 8 stamens. Female flowers are 4 mm in length and have free oblong petals as well as larger sepals. [10]. Fruits are 3–4 cm long, trilobite ovoid capsules that split from three cells. Each fruit has three seeds, each of which is enormous, rectangular, and 2 cm long, with a pleasant flavor [11].

Curcas is its birthplace, and it can be found throughout northeastern South America and the dry parts of Mexico [12]. The plant is thought to have spread to other African and Asian nations through the islands of Cape Verde and Guinea Bissau [13]. The majority of Jatropha species are thorny, seasonally dry habitats such as The lush Amazon area is devoid of grassland-savannah and thorn forest scrub. Its present distribution is as follows: Curcas shows that introduction has been more effective in the drier sections of the tropics. It is now widely grown as a decorative tree or as a sturdy hedge in many tropical and subtropical countries of Africa and Asia [14]. *J. curcas* thrives in temperatures ranging from 15 to 40 degrees celsius. It thrives at middle altitudes and in humid environments. The plant is not affected by the duration of the day and can bloom at any time of year [13].

3.2. Chemical Constituents

Jatropha curcas is a member of the Euphorbiaceae family and is utilized as a medicinal plant as well as an ornamental and multipurpose shrub. This plant has a variety of current and potential applications, particularly in the medical field. There are numerous medical applications for *J. curcas.* The researchers had explored and studied the curcas plant sections. Traditional medicine and veterinary medicine have traditionally used all components of the Jatropha plant (seeds, leaves, bark, and so on). It frequently contains mixtures of several chemical components that can help people's health in many ways: singularly, additively, or synergistically [7]. The chemical compositions of several portions of this plant are utilized to treat various ailments [15].

3.2.1. Leaves

A variety of chemicals have been identified from *Jatropha curcas* isolates. The leaves contain the flavonoid apigenin, as its glycosides vitexin and isovitexin, as the sterols stigmasterol, - D-sitosterol, and its -D-glucoside [16]. In addition, curcas leaves also contain alkaloids, steroid sapogenins, triterpene alcohol, 1-triacontanol, and tripene alcohol, which were extracted using ethyl acetate from a mixture of 5-hydroxy pyrrolidin-2-one and pyrimidine-2, 4-dione.

3.2.2. Stem bark

The stem and bark extracts contained secondary metabolites such as saponins, steroids, tannins, glycosides, alkaloids, and flavonoids. According to Shimada (2006), tannins have been discovered to form irreversible compounds with proline-rich proteins, reducing cell protein formation. Curcas stem bark extracts were identified to contain saponin, which has been shown to help in inflammation treatment. Alkaloids possess excellent human effects, leading to the development of effective painkiller formulations [17]. Flavonoids, which have antibacterial, anti-inflammatory, antioxidant, and anti-angiogenesis activities, are another secondary metabolic product discovered in curcas stem bark extract [18].

3.2.3. Latex

Tannin, saponin, wax, and resin are all found in latex.Curcain, a proteolytic enzyme, may be extracted from latex by precipitating it with alcohol and acetone, both of which are abundant in latex, and curcacycline A, a novel cyclic octapeptide produced from latex, inhibits the classic human complement and T-cell proliferation route [19]. Lastly, Curcacycline B, a novel cyclic nonapeptide, can boost cyclophilin B's rotamase activity.

3.2.4. Seeds

Humans and animals are both poisoned by the seeds in general. Curcin is a toxic protein extracted from the seeds that are also high in phorbol esters. JEA esterase, JEB esterase, and lipase were also discovered in curcas seeds [20].

3.2.5. Roots

Phytochemical analysis of the extracts revealed the presence of many secondary metabolites, including steroids, alkaloids, and saponins. *J. curcas* roots contain diterpenoids, jatropholone A, jatropholone B, and jatropholol [21].

3.3. Traditional Uses

Jatropha curcas (Euphorbiaceae) is located in South America's northeastern region, America and Mexico's dry lands.It is a versatile plant currently grown in tropical and subtropical areas and is often used for folk medicine to alleviate ailments. It possesses Antihypertensive, Antiinflammatory, Antioxidant, Antineoplastic, Analgesic, Anti diarrheal, Anti-bacterial activities that were found on this planet [22]. Infusion, decoction, maceration, and oral, topical, and bath treatments are all used to extract the plant's leaves, stems, roots, seeds, and latex.

Table 1. Different parts of Jatropha curcas L are used for various purposes. [23]

Plant Part	Region	Form	Use
Leaves	West Africa	Decoction	Lactogogue, rubefacient, suppurative
		Decoction + Lime juice	Fever, convulsion, anthelmintic
		Ash from burn leaves	To draw out guinea worm sore
		Infused of young leaves	Urinary complaints
		Boiled(J.curcas + Azadirachta + Indian + Carica papaya)	Malaria (drink and bath)
	Nigeria	Boiled leaves (J. curcas + Syzygium guineense) + palm oil	Diabetes
	Cameroon	Raw leaves	Arthritis; against abscess in the stomach
	Benin	Leaf decoction	Oedemas and cough
		Decoction of leaves + roots + fruits of Xyæopia ethiopia	Drepanocytosis
		Fresh leaves + kaolin pounded in water	Haemorrhoids
	India	Leaf (paste + crude)	Jaundice and liver troubles
		Tender leaves	Headache
		Leaves paste	Burn spot; chest inflammation, congestion, headache, hypertension, eczema, galactagogue
		Leaf juice	Amenorrhea and oligomenorrhea
		Leaf paste oj J. curcas and J. gossypifolia	Night blindness
		Infusion	Diabetes

		Leaf poultice	Furuncle, hair loss
		Crushed leaves	Haemostatic, styptic, hair loss, bleeding wounds, snake bite
	Colombia	Decoction	Venereal diseases
	Costa Rica	Poultice	Erysipelas and splenosis
	Barbados	Tea	Marasmus Jaundice
	Panama	Leaf Poultice	Rubefacient for paralysis rheumatism and galactagogue
	Guatemala	Heated Leaves	Lactagogue
		Crushed Leaves	Haemostasis, styptic, hair loss, bleeding wounds, snake bite
Latex		Paste	Dressing wounds, inflamed tongues and ulcer
	West Africa	Latex + Salt	Carious teeth, mouthwash and tooth came out in children
	Benin	Dried Latex	Leucorrhagia, urethritis
	Mali	Paste	Stop bleeding against infection
	Cuba	Paste	Toothache
	Columbia	Paste	Burns, haemorrhoids, ringworm, ulcer
	Bahamas	Decoction	Heartburn
	India	Latex + Salt	Eczema, scabies, wounds, burn cancer, toothache, mouth ulcer, cracked lips, otorrhoea, cold and cough itching of genital organs
Roots	India	Decoction	Mouthwash for bleeding gum and toothache, eczema, ringworm
		Root bark decoction	Mouthwash for toothache and sore throat;abortifacient
	Venezuela	Decoction	Dysentery
	West Africa	Decoction	Gonorrhea
		Powdered root bark	Dressing wound and sores
		Infusion of root	Rheumatism, dyspepsia,

			diarrhea
		Rock pulp + Xylopia sp. fruits	Dysentery, incontinence
	Cameroon	Decoction of root 0.5 kg in 5.1 water + indigenous salt	Hypertension Sexualy transmitted disease Arthritis, gout, jaundice, purgative
Seed	India	Gargle of fresh stem juice	Arthritis, gour, jaundice, purgative Toothache; angular stomatitis Constipation Rheumatism, dermatitis, herpes, dropsy Dysentery, stomach disorders, rheumatism
	Mali		Laxative
Stem	West Africa	Roasted seeds + shea butter	Dropsy, gout, paralysis, skin ailments
		Preparations containing seeds	Guinea worm infection, tumors, syphilis, skin infestation, abortifacient
		Leafy twigs pounded in water	Glass of the filtrate is drunk once a day for malaria
		Young twigs paste + black pepper	White discharge (given twice a day)
		Twigs	Chewing for; pyorrhea, gum and teeth problems
		Juice	Dysentery (orally 3 times a day) Source, haemostatic, wound
		Crushed stem heated with oil	As massage for muscles pain, hematoma
Bark	India	Infusion + salt	Diarrhea, dysentery
		Water extract mixed with milk	Diabetes
		Bark powder paste	Muscular pain
		Bark juice	Scabies
		Bark	Mouth sore
		Gargle of fresh stem juice	Toothache, angular stomatitis,
Oil	West Africa		Itch, herpes, as rubefacient

	India		Eczema, skin disease, rheumatism Leukoderma, sores and pimple Massage for arthritis, rheumatism, paralytic affections, leprosy
Fruit	India	Fruit powder	Constipation
	Nigeria	Fruit burnt into ashes and taken with oaoa	On fracture, swelling, headache Diabetes
	Benin	Fruit powder	Constipation
	Mali		Dysentery, stomach disorders, rheumatism Laxative

Due to its multiple industrial applications and therapeutic benefits, *Jatropha curcas*, a versatile, drought-resistant perennial plant of the Euphorbiaceae family, is becoming increasingly economically important. *J. curcas* has long been thought to be helpful in the treatment of a number of illnesses, and the plant is still used to treat a variety of ailments in many countries [24].

3.4. Pharmacological Activities

3.4.1. Anti-inflammatory effects

J. curcas leaves methanolic extract had anti-inflammatory properties in Wister albino rats [26]. Utilizing the method of edema induced by formalin in rats' paws, aqueous extracts from the plant's leaves and bark demonstrated remarkable anti-inflammatory activity [27]. Topical application in paste form of its root powder possesses anti-inflammatory activity in both mice and rats. This may be due to the effects on numerous mediators and arachidonic acid metabolism, including cyclo-oxygenase pathway, which leads to prostaglandin formation, and anti-proliferative activity that minimizes formation of granular tissue and migration of leukocyte from vessels [28] .

In acute carrageenan-induced rat paw edema, the alcoholic preparation of *J. curcas* leaves, stems, and roots showed notable antiinflammatory activity [29]. Anti-inflammatory activities of the plant parts preparations are associated with its strong iNOS inhibition [30].

3.4.2. Antioxidant Activity

Table 2 lists the antioxidant properties of several extracts from the plant. The antioxidant activity of water, ethanol, and methanol extracts from *J. curcas* roots, leaves, nodes, and stems was investigated. Plant extracts from root and bark were shown to have a greater hydroxyl scavenging activity than ascorbic acid and were able to scavenge hydroxyl in a concentration-dependent way.

Table 2. Antioxidant activity of *Jatropha curcas* plant [30-33]

Part of the plant	Extract	Activity
Nodes, leaves, stems and roots	Ethanol	Antioxidant activity is measured using the DPPH (1,1-diphenyl-2-picrylhydrazyl hydrate) assay. The crude extract from roots had the strongest free radical scavenging activity, with a maximum inhibition of 0.521 mg ml^{-1} [31].
Latex, leaf, root and stem bark	Methanol	Antioxidant activity was measured using DPPH and nitric oxide (NO) scavenging activity tests. Latex and leaf both showed good NO scavenging activity. The root and stem bark were active to various degrees. In a dose-dependent manner, NO scavenging activity was identified in all samples [30].
Stem bark	Methanol, ethanol, and water	Antioxidant activity was measured by DPPH, 2, 2'-azino-bis-(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), ferric reducing, nitric oxide (NO), superoxide anion (O2), and hydrogen peroxide (H2O2) assays. Butylated hydroxytoluene (BHT) and ascorbic acid were used as standards. The more concentrated the substance, the more DPPH scavenging action it has. When compared to the standard BHT, the methanolic extract showed the highest DPPH scavenging activity, followed the aqueous and ethanolic extracts, all of which had a robust DPPH scavenging activity. The extracts' ability to suppress the ABTS radical was likewise concentration dependent. ABTS+ had a high scavenging activity for all three extracts. When compared to BHT, all extracts had stronger superoxide radical scavenging activity [32].
Root bark	Aqueos, ethanol and methanol	When compared to ascorbic acid, they are more effective in scavenging hydroxyl in a concentration-dependent manner and have a higher hydroxyl scavenging activity [33].

3.4.3. Antimicrobial Activity

Its antimicrobial activity was discovered in crude aqueous, methanolic, and hexane extracts of *J. curcas* from various plant sections [34]. This plant is antifungal, and it can kill *Aspergillus fumigatus, Aspergillus niger, Bacillus subtilis, Phymatotrichopsis omnivora, Candida albicans*, and other fungi that cause a variety of diseases in humans and plants [33, 35-37].

3.4.3.1 Leaves

Methanol extracts [39-40] and ethanol extracts [41] have been shown to have antimicrobial action when extracted from *J. curcas* leaves. Antimicrobial activity was discovered in *J. curcas* stems and leaves' latex. It was effective against *E. coli, B. subtilis, S. aureus, P. aeruginosa, S. pyogenes, C. albicans,* and *Trichophyton sp* [42]. Secondary metabolites present in latex, including flavonoids, saponins, and tannins may be the cause for the antibacterial activities [43].

3.4.3.2. Root

J. curcas is demonstrated to possess antibacterial activity in vitro against a variety of pathogens that cause illnesses, including STD [44]. Results showed significant antimicrobial action against target pathogens, being 0.75 µg/mL the lowest MIC. It proved the plant's potency in treating infections such as STIs.

Root extracts of the plant in hexane, ethyl acetate, and methanol demonstrated strong antibacterial activity. The root bark methanol extract, on the other hand, showed strong broad spectrum activity [44]. Grassroot bark preparations from *J. curcas* have been shown to suppress growth of gram-positive *S. aureus* and gram-negative bacteria such as *K. pneumoniae, P. aeruginosa, E. coli,* and *S. typhimurium* in acetone, chloroform, ethanol, and methanol [33, 35-36, 45].

3.4.3.3. Stem

Several investigations have revealed that *J. curcas* stem bark possesses antibacterial properties. Secondary metabolites steroids, tannins, saponins, glycosides, flavonoids, alkaloids, and dark blue dye were discovered in phytochemical screening of crude ethanolic, aqueous, and methanolic extracts of *J. curcas* stem bark extracts. These chemicals are recognized to be physiologically active, which helps *J. curcas'* antibacterial properties. These secondary metabolites' antibacterial action is mediated by a number of ways. *J. curcas* stem bark was shown to contain active antimicrobial chemicals, making the plant a potential candidate for antibiotic and antifungal drug bioprospecting [46].

J. curcas has also yielded methanol, crude petroleum ether, and ethyl acetate extracts, as well as two refined components, JC-1 and JC-2, out of its stem bark [47]. The plant's methanolic extract and methanolic extract fractions with ethyl acetate and chloroform demonstrated antibacterial activity [48].

3.4.3.4. Seeds

Seeds and seed cake of *J. curcas* was found to possess antibacterial effects in numerous researches. Acetone, hexane, dichloromethane, and methanol extracts out of the seed cake demonstrated to have antibacterial action against gram-positive and negative microorganisms [49].

An ethanol extract from its seed cake was also discovered to possess antifungal activities. Ethyl acetate, methanol, and hexane extracts from its seed also had antimicrobial action. Diterpenes and other chemicals drawn from *J. curcas* demonstrated to possess antibacterial properties in numerous investigations. An ethanol extract of *J. curcas* seed cake was also revealed to bear antifungal effects [50]. Extracts of *J. curcas* seed in methanol, ethyl acetate, and hexane also demonstrated antibacterial activity [51].

3.4.3.5 Sap

When administered to gram positive and negative bacteria, the sap of *J. curcas* exhibits a powerful antimicrobial effect. The sap was poisonous not only to bacteria but also to parasites. Incubation of eggs of *Ascaris lumbricoides* and *Necator americanus* in pure and 1:1 diluted sap revealed no embryonation. In the sap, mosquito eggs could not develop [52]. The oil's methanol extract was also evaluated on two *Schistosoma mansoni* larvae stages. The extract manifested toxicity to the two larvae, cercariae being more susceptible than miracidia. Because they cause Schistosomiasis, one of the major deadly parasite diseases, reducing the growth of *Schistosome sp*. became critical [53].

3.4.4. Anticancer activity

J. curcas is among the plants utilized for cancer therapies in Mexico [54]. *J. curcas* produces a lot of diterpenes, a secondary metabolite. These chemicals have been shown to be both cytotoxic and tumor inhibitors [55]. *J. curcas* leaf methanolic extract fraction demonstrated antimetastatic activity [56]. On an HT-29 cell line, extracts out of the leaf, root, and stem bark displayed cytotoxic action. Root extracts were more active than leaf and stem bark extracts, suggesting that they could be used to treat cancer [30].

Several articles have revealed anticancer activity of diterpenes extracted from the *J. curcas* plant. There have been reports of curcusone B having antimetastatic activity against cholangiocarcinoma cell line [55] and four human cancer cell lines [57], gastro-protective property out of jatropholone in mice [58], caniojane cytotoxicity in African green monkey kidney fibroblasts, antituberculosis actions on *M. tuberculosis* H37Ra [59], and anti-proliferative [60].

In vitro, however, jatrophalactam exhibited no substantial inhibitory impact against a cell line of human lung cancer, colon cancer, or epidermal squamous cell carcinoma, according to a study [61]. Jatrophalactone was found to have cytotoxic action in another investigation [62]. Proteins extracted from *J. curcas* have been investigated for decades for their anticancer properties [63]. Ribosome-Inactivating Proteins curcins were identified from the seeds. These proteins are thought to be cell-killing substances, as they can prevent the creation of cell-free proteins. Curcin was also found to exhibit anticancer properties in *E. coli* strain M15 [64]. In the cell-free translation system, protein production was stopped.

Jatropha contains anti-cancer alkaloids in its leaf, bark, and latex, including jatrophine, jatropha, curcain, curcacycline A, flavonoids, glycosides, sapogenins, and tannins [19,22,65]. Tannins have been proven to have anticancer properties and can be utilized to prevent cancer, propsing that the plant could be an origin of essential bioactive chemicals for treating ang preventing cancer [66]. Curcin, a ribosome inactivating protein, could be a promising anticancer and immunosuppressive therapeutic candidate. Curcusone B, a compound derived from the root, exhibits antiproliferative properties and inhibits the proliferation of cancer cell lines [67].

3.4.5. Antiviral activity

In cultured human lymphoblastoid CEM-SS cells, a methanol extract from the plant was found to have a mild cycloprotective activity against HIV [68]. *J. curcas* branch preparations were investigated for their effects on HIV reverse transcriptase, HIV-induced cytopathic effects in cultured cells, and HIV-protease enzymes [69]. With minimal cytotoxicity and a high selectivity index, the plant's branch aqueous extract showed noteworthy suppression of HIV-induced cytopathic effects [67]. It was discovered that phorbol esters from the plant may be used to synthesize prostratin and DPP. This

compound promotes the characterization of excellent clinical candidates for HIV treatment [70]. *J. curcas* latex has an inhibiting effect on the Water Melon Mosaic Virus. Steroids' antiviral properties have been proven [71], hence steroidal substances found in *J. curcas* stem bark isolates are of great interest.

3.4.6. Antidiabetic activity

Because of its long history of use in blood sugar management, a study found that a 50 percent ethanolic extract from *J. curcas* leaves had antihyperglycemic benefits when given orally to alloxan-induced diabetic mice [72]. The extract had strong antihyperglycemic properties. The reduction was comparable to that seen in rats given conventional glibenclamide. Furthermore, the extract considerably decreased the rats' cholesterol and triglyceride levels.

3.4.7. Analgesic activity

With a writhing test induced by acetic acid, researchers found that methanolic extract from *J. curcas* leaves has analgesic efficacy in mice. When contrasted to the analgesic effect of the reference medicine paracetamol, the methanolic extract significantly lowered the amount of mice writhing [26]. A hot plate and acetic acid-induced writhing reflex in mice and a tail flick test in rats were used in another investigation in vivo to analyze the analgesic effects of the methanolic leaf extract from the plant. Oral therapy with the leaf extract and reference medicine acetylsalicylic had a considerable analgesic effect in mice and rats, increasing pain time dose dependently. Also, the extract reduced the amount of abdominal contortions [73]. When compared to the traditional treatments pentazocine and paracetamol, another study found that its stem and roots' alcoholic extract had a remarkable effect and reduced yeast-induced pyrexia [74].

3.4.8. Hepatoprotective activity

In rats, methanolic fractions from its leaves were tested for their ability to prevent hepatocellular carcinoma caused by aflatoxin B1 when given orally [75]. The methanolic fractions lowered serum enzymes, lipid and bilirubin levels, but elevated uric acid and protein levels. It lowered the occurrence of aflatoxins-induced liver lesions, hepatic necrosis, and lymphocytic infiltrations, according to liver histopathology.

3.4.9. Wound healing activity

Many cultures throughout the world have documented the usage of various sections of *J. curcas* for wound healing [9,76-77]. In mice, the proteolytic enzyme Curcain produced from latex through alcohol and acetone precipitation, demonstrated to have wound healing action [78].

J. curcas extract was found to have cicatrizant action in mice [79]. In Wistar albino rats, the efficacy of crude bark extract was also examined. By enhancing the breaking strength of granulation tissue, wound constriction, skin breaking strength, dry granulation tissue weight, and hydroxyproline levels, the extract speeds up the healing process [80].

A herbal ointment with methanolic leaf extract was combined with 10g of basic ointment base to evaluate wound healing potential. Every three days, the wound was treated with ointment that was applied topically until it healed entirely. In a dose-dependent way, methanol preparation mixed in an ointment base promoted faster wound healing rates and shortened epithelialization duration compared to blank and gentamicin ointment (1%) [81].

Using an incision and excision wound model, researchers investigated wound healing activity of ointment with a white soft paraffin core and 5 and 10% (w/w) extract of J. curcas stem bark in albino rats [82]. In both wound models, the extract ointment's effect was significantly greater than the control group, indicating significant wound healing. All tensile strength, tissue repair, hydroxyproline content, and histological investigations demonstrated remarkable differences to the control.

3.4.10. Anticoagulant and procoagulant activity

One of the known classical uses of the plant's latex is as a styptic or haemostatic: once latex is administered topically to incisions and gushing injuries, the hemorrhage ends immediately [83]. These observations suggest that this plant contains pro-coagulant action. According to a study, its latex has both procoagulant and anticoagulant effects, allowing human blood to clot faster. Diluted latex, on the other hand, increased the time it took for the blood to coagulate. The manifestation of antagonistic activities was attributed to the latex's solvent partitioning with butanol and acetyl acetate. Procoagulant activity was seen in the acetyl acetate fraction at low concentrations, but the butanol fraction possessed strongest anticoagulant activity. Dilute latex is an anticoagulant, whereas latex is a blood coagulant [76].

3.4.11. Antifertility activity

Oral dosing of *J. curcas* extracts in methanol and dichloromethane when pregnant rats were given curcas fruits, they were discovered to induce an anti-fertility property. Its components produced fetal resorption by terminating gestation occurrence at a preliminary phase following fertilization [84]. Albino female swine were fed crude extracts of its seeds. It was there that they discovered an anti-implantation as well as contraceptive effects [85]. In addition, its oil when set at a dosage of 2 ml kg1 BW, prevented the birth of a pregnant dog [86].

3.4.12. Antidiarrhoeal activity

J. curcas roots extracts in petroleum ether and methanol had anti-diarrhoeal action in albino mice. The postulated underlying mechanism was a mixture of decreased intestinal propulsive movements and prevention of enhanced prostaglandin synthesis [87]. According to a previous study, tannins interacted with proteins to cause tanning, which is effective for treating ulcerated/inflamed tissues [88]. Herbs having tannins as their main component are used to treat intestinal issues including diarrhea and dysentery. *J. curcas* is employed in herbal remedy therapies as a result of these findings [89-90].

3.5. Toxicology

Jatropha curcas is a widely grown flowering plant that belongs to the Euphorbiaceae family. This plant is often utilized as a protective hedge over gardens and fields in most rain-forest areas. *Jatropha curcas* is commonly used in medications and cosmetics as well as biodiesel due to its high-oil-content seeds. Despite its medicinal properties, Jatropha plants are known for their poisonous nature, which is mostly due to latex and seeds [91]. The *J. curcas* is poisonous in all parts, however, its seeds contain the most toxins, making them particularly hazardous. Curcin, a proteolytic enzyme, and curcacycline, an octapeptide, both found in the latex inside the seed which exhibits anticomplementary activity in vitro [92].The extracted oil from curcas seeds contains phorbol, cyanic acid, and curcanoleic acid that are hepatotoxic to humans [93]. These toxalbumins can disrupt ribosomes, which are important for protein synthesis, resulting in cell death and tissue damage where its primary target are mucous membranes in the mouth, esophagus, and gastrointestinal tract with toxic symptoms of acute gastroenteritis and electrolyte loss [94-95].

In different organisms, the *Jatropha curcas* plant has different biological activity. Extracts of Jatropha seed, oil, root, leaf, and bark, as well as ingesting of plant components, are responsible for the majority of the effects. The results of the toxicity varied depending on the plant components utilized, concentration, mode of administration, and the organism studied. Any improper disposal of *Jatropha curcas* plants in terrestrial or aquatic areas have a wide range of consequences. Table 3 shows the toxicity of *Jatropha curcas* plants in several species.

Table 3. Effects of Jatropha Curcas Plant Parts on Various Organisms [55]

Species	Plant parts	Test material	Properties
J. curcas	Plant	Chloroform and acetonitrile	Molluscicidal activity
	Fruit	Methanol, chloroform, and petroleum ether extract	Toxic to rats (pregnancy-terminating effects)
	Seed	Powdered seed	Orally toxic to goats,a sheep,a calves,a and humans (oral)
		Powdered seed in the diet	Toxic to chickens
		Raw or cooked seed	Toxic to rats (oral)
		Aqueous extract	Molluscicidal activity
		Methanol extract	Toxic to rats (intraperitoneal)
		Petroleum ether extract	Insecticidal activity
	Kernel meal	Mixed in the diet	Toxic to rats (oral); toxic to pigs (oral)
	Defatted seed cake	Mixed in the diet	Toxic to rats (oral)
	Oil	Methanol and ethanol extracts	Molluscicidal and insecticidal activities; hemolysis in rabbit red blood cells; tumor promoting in mice skin
			Toxic to rats and rabbits (topical)
		Petroleum ether	Molluscicidal, ovicidal, and insecticidal activities; toxic to rats (oral and topical); pregnancy-terminating effects in rats
	Latex		Antiparasitic activity
	Aerial parts	Aqueous extract	Cytotoxic activity
	Leaves	Petroleum ether and benzene extracts	Insecticidal activity
		Methanol extract	Toxic to rats (oral); antischistosomal and cytotoxic activities
		Dichloromethane, methanol and hexane extracts	Antibacterial activity

3.5.1. Humans

A study by Rai and Lakhanpal [96], demonstrated the toxicity effects of *J. curcas* seeds among school children in Mauritius. The said children have manifested abdominal pain, vomiting, and diarrhea upon consumption of *J. curcas* seeds. The symptoms started 30 minutes to 2 hours upon ingestion, and recovery may take 24 hours. IV fluids, antispasmodics, and antiemetics were used to treat all of the children symptomatically. GIT symptoms such as burning sensation in the throat, vomiting, diarrhea, and abdominal discomfort were experienced by all of the children who were poisoned by Jatropha. Vomiting and diarrhea started 15 minutes after consumption, and intense abdominal pain started 30 minutes later. Jatropha toxicity has also been linked to depression and circulatory collapse in children. Another research by Singh [97] about Jatropha poisoning in children shows the same manifestation and symptoms to those reported by Rai and Lakhanpal (967).

3.5.2. Mice/Rats

Feeding curcas seeds at concentrations of 50 percent and 40 percent in the diet resulted in a significant mortality rate, however feeding them at concentrations of 20%, 10%, 5%, and 1% in the diet did not result in death [98]. Diarrhea, imposture, despondency, and lateral recumbency were the common poisoning symptoms. The severity of pathological disorders in the small intestines, liver, heart, kidneys, and lungs was associated with the quantity *J. curcas* in the diet. On macroscopic examination, intense catarrhal enteritis and blood extravasation in the intestinal canal was observed. The small intestine mucous membranes seemed enlarged, with brittle epithelial membranes. There was also edema in the lungs, as well as a clogged liver, kidneys, and heart. Moreover, the microscopy findings revealed catarrhal enteritis in the digestive system. Mucus including desquamated cells and leukocytes covered the intestinal mucosa in exudate. The cells degenerated while the liver was low on glycogen, and the veins and sinusoids were expanding at a rapid pace. In addition, congestion and atrophy of muscle fibers in the heart, as well as reduction of the glomerular tuft and cellularity in the kidney have been observed due to polymorphonuclear cell infiltration and glomerular endothelial cells.The lungs showed obstruction of the capillaries and hemorrhage into the alveoli. Curcas kernel at a dosage of 0.23 mg/g in diet feed was found to be very hazardous to a 28-day-old male Wistar rat because of the presence of phorbol ester. Prior to death, the rats had a low desire to eat, as well as weight loss, diarrhea, and problems with motor skills. The vital organs showed signs of atrophy on a physical examination. The kidney, heart, brain, and liver are all normal on microscopic examination, but the kidneys, heart, and brain have gained weight [99]. In rats, the *J. curcas* methanol extract had a toxic impact at doses of 25.19 mg and sublethal doses of 10 and 13.80 mg. The extract was reported to induce a progressive decrease in red cell counts, cell volume, and blood concentration when tested hematologically [100].

3.5.3. Chickens

Jatropha curcas seed intoxication in brown Hisex chicks was characterized by growth depression, hepatic nephropathies, bleeding, and congestion when forced-fed with 0.1 or 0.5 percent of the diet for 4 weeks. The signs and symptoms of *J. curcas* seeds intoxication include congested heart and intestine, fatty liver, and swollen kidneys [101]. In another study, broiler performance and internal organ development were negatively affected by diets containing *Jatropha curcas* seeds meal. Increased JCM levels reduce broiler live weight, weight gain, and feed intake, as well as affect internal organ development in which the testis becomes atrophic, with smaller seminiferous tubules bordered with active sertoli cells and infrequent spermatogonia [102].

3.5.4. Sheep/Calves/Goats

Through a stomach tube, young Nubian goats weighing 8 to 22 kg were given crude ground *J. curcas* seeds at a dose of 0.25-10 grams per kilogram each day. Goats died in 2 to 4 days after receiving doses of five and ten g/kg/d. A liver biopsy indicated a 50 to 60 percent decrease in glycogen levels, fatty modifications, and death of hepatocytes. Low water consumption and glucose levels, as well as diarrhea, low appetite, dehydration, and deep-eyedness, were all observed [103]. In another study, desert sheep and Nubian goats show similar symptoms reported by Adam and Magzoub [103] after receiving 0.05, 0.5, or 1 g/kg/d of *J. curcas* seeds. The main pathological changes identified were hemorrhagic enteritis, fatty liver, pulmonary congestion, edema, and straw-colored fluid in the cavities. Increased AST activity, ammonia, potassium, and sodium levels, as well as decreased protein and calcium levels in serum, were also identified [104]. Similarly, Ahmed and Adam [105] discovered that feeding *J. curcas* seeds into calves at 0.25, 1, or 2.5 grams per kilogram induced severe complications and mortality in only 19 hours. While calves fed with 0.025 g/kg/d for 14 days exhibited signs of toxicity and death between ten and fourteen days, with symptoms comparable to those reported by Ahmed and Adam [104] in sheep and goats.

3.5.5. Snails

In many tropical areas, snails serve as intermediate hosts for schistosomes, and in Africa, they serve as carriers for the lethal disease schistosomiasis [106]. Snails of various species demonstrated a high level of sensitivity to chemicals discovered in J. extracts, allowing for the treatment of snail-borne diseases. The Sudanese *J. curcas* seeds were found to be toxic to Bulinus truncatus (LC100, 2ppm) and Biomphalaria pfeifferi (LC100, 50ppm) [107]. Crude extracts of curcas seeds from Bindura and Kariba, Zimbabwe, were identified to have molluscicidal activity against Biomphalaria glabrata and Bulinus globosus snails, with Biomphalaria glabrata seeming to be the most sensitive to unripe seed extract (LC50, 282 and 389 mg) while Bulinus globosus being the most sensitive to overripe fruit seed extract (LC50, 389 mg) [108]. Methanolic extracts had the maximum toxicity against cercariae and *Biomphalaria glabrata* (LC100, 25ppm) *and Bulinus truncatus* and *Bulinus natalensis* (LC100, 1ppm) [53]. Furthermore, *Jatropha curcas*' poisonous effect is due to the influence of phorbol esters [109].

4. CONCLUSION

In our world where there is a constant pursuit of the next plant that can be cultivated into an effective medicine with numerous applications, Jatropha curcas L. stands out among the rest due to its promising curative utilities necessary in creating pharmaceutical products. Relevant medicinal

alkaloids such as; jatropha, curcain, glycosides, flavonoids, etc. have been discovered in the plant's bark, leaf, and also its latex which are responsible for the plant's benefits. Multiple research has shown its ability as an anti-inflammatory, antioxidant, antimicrobial, anticancer,antidiabetic, analgesic, hepatoprotective, wound healing, anticoagulant, antifertility, antidiarrheal medicinal abilities. Nonetheless, much more scientific research is required to examine the plant's medical value for the compounds to become viable treatments. Toxic effects as well as other risk concerns must be considered while assessing the therapeutic capabilities of the Jatropha plant in order to fully integrate the plant in the pharmaceutical industry.

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