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Jatropha curcas L.: A sustainable resource for biofuel feedstock with medicinal and commercial attributes

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The Euphorbiaceae family includes *Jatropha curcas* L., a tree with the greatest potential for producing biofuel. A perennial, drought-resistant, and extremely adaptable plant, it is gaining prominence in the biodiesel industry. Ratanjyot, Nutmeg plant, Barbados nut, and Physic nut are some of its more well-known names. *Jatropha* trees grow 3 to 6 meters tall, with heart-shaped green leaves, smooth, grey bark, and latex. A large shrub or small tree known as *Jatropha curcas* L. produces seeds containing inedible oil. *Jatropha curcas*, a tropical plant, can be cultivated as a commercial crop or on farms in areas with varying precipitation levels, ranging from low to high. Plants can be grown as a crop or as a border hedge to keep grazing animals away from crops and minimize soil erosion. *Jatropha* leaves, seeds, and bark have been used medicinally since ancient times, treating constipation, anthelmintic difficulties, and stomach illnesses. Many different secondary metabolites were discovered when physio-chemists studied the extracts and latex, such as alkaloids, saponins, curcin, curcusones-B, curcain, lectin, curcacycline A, phorbol acetate, tannins, steroids, etc. The *J. curcas* plant is used in various ways, including replacing fossil fuel diesel for domestic purposes, soap production, and raw materials

for dye. Due to its antiviral, anticancer, antidiarrheal, larvicidal, and insecticidal activities, it is currently receiving significant interest. It is a versatile tree species suitable for agroforestry and other afforestation programs. Exploration has been conducted into plant potential utilization for diverse purposes.

Keywords: *Jatropha curcas, ratanjyot, phytochemicals, biodiesel, oil*

INTRODUCTION

Energy plays a fundamental role in enhancing quality of life on the Earth. Sustainable fulfillment of escalating energy demand represents a significant challenge in the 21st century. Nowadays, considerable attention has been given to biodiesel which acts as a renewable and biodegradable energy source. *Jatropha curcas* has emerged as a recognized energy crop, allowing countries to cultivate their own renewable energy sources while enjoying numerous promising benefits, such as controlling soil erosion, producing soap, and serving various medicinal purposes through its different parts. The fruit of the Jatropha plant holds great versatility, finding utility in multiple areas including fuel production (Silitonga et al., 2011). *Jatropha curcas* L. is commonly known as Barbados nut, termite plant, fig nut, black vomit nut, curcas bean, purge nut, physic nut, purgeer boontjie, purging nut tree, bubble-bush, ratanjyot (Divakara et al., 2010). Originally native to South America, *Jatropha curcas* was introduced to Thailand by the Portuguese around 200 years ago for soap production using its oil. These trees typically grow to heights of 3 to 6 meters, featuring heart-shaped green leaves, latex, and smooth grey bark (Gudeta, 2016). *Jatropha curcas* is a large shrub or small tree that produces non-edible oil seeds. While several Jatropha species exist worldwide, this particular species is most prevalent in Nigeria. This plant exhibits drought-resistant properties and can be cultivated in areas with minimal rainfall. *J. curcas* is an ideal plant for rapid domestication and efficient growth compared to other woody species. However, the names assigned to this plant can vary by location or country (Oskoueian et al., 2011). The oil derived from 40 to 50 percent of *Jatropha curcas* seeds is considered a promising alternative fuel source and can be used to substitute diesel without engine modifications (Pramanik, 2003). Phytochemical studies have identified phenolic, saponin, flavonoid, and alkaloid compounds in different parts of the *Jatropha curcas* plant. These bioactive plant chemicals have attracted significant attention due to their antitumor, antibiotic, anti-inflammatory, and antioxidative properties (Rathee et al., 2009). *Jatropha curcas* latex includes anti-cancer alkaloids such as Jatrophin and Curcain (Islam et al., 2011). Through programs, Jatropha oil is marketed as a widely cultivable biofuel crop in India. Research institutes and women's self-help organizations, which employ microcredit systems to alleviate poverty among semiliterate Indian women, have made substantial investments in large-scale plantations and nurseries (Fairless, 2007). In 2007, Goldman Sachs identified *Jatropha curcas* as one of the leading candidates for biodiesel production (Mofijur et al., 2012). Figure 1 illustrates the different parts of *Jatropha curcas*, including its fruit, shell, seed, husk, seed kernels, seed cake, and seed oil.

This plant's portions cure a variety of human and veterinary diseases. White latex disinfects children's mouth infections. Renewable energy alternatives have been sparked by fluctuating fossil fuel costs and environmental concerns. Because it can be appropriately adjusted for existing diesel engines, biodiesel is the most effective replacement for fossil fuels. It is a fuel made from vegetable oils with many petroleum diesel characteristics. Biodiesel is a highly effective, non-toxic, and biodegradable substitute for fossil fuels (Abhilash et al., 2011).

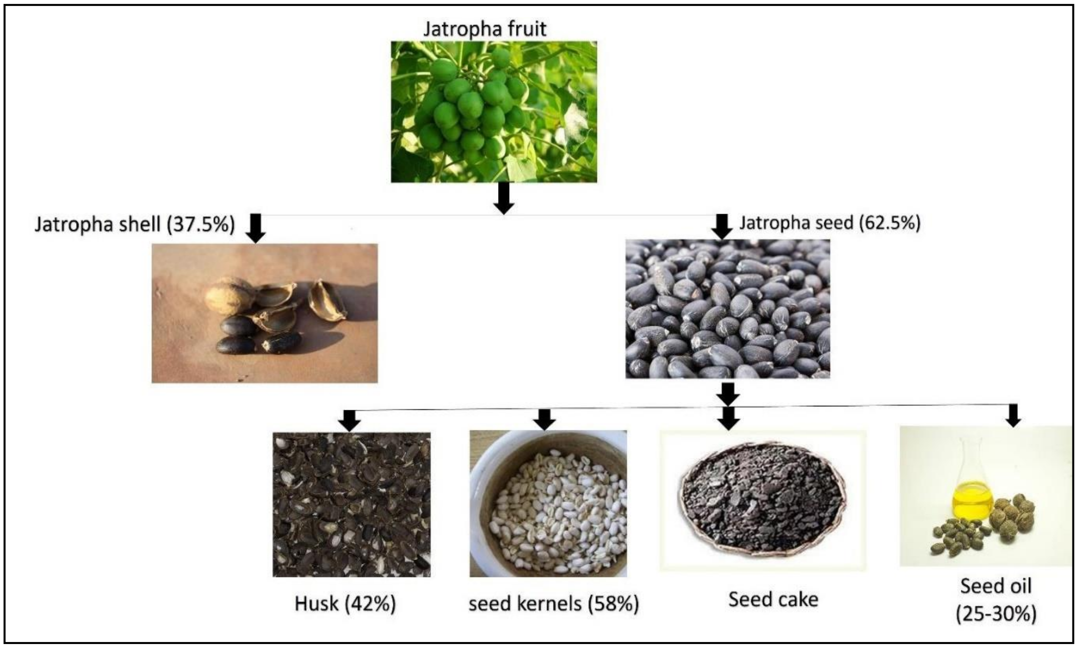


Figure 1. Different parts of *Jatropha curcas*: fruit, shell, seed, husk, seed kernels, seed cake, and seed oil.

Scientific classification

Table 1. Taxonomic classification of *Jatropha curcas* (Sharma et al., 2012)

Kingdom	Plantae
Division	Magnoliophyta
Order	Malpighiales
Family	Euphorbiaceae
Subfamily	Crotonoideae
Tribe	Jatropheae
Genus	*Jatropha*
Species	*Curcas*

Origin and Geographical distribution

Since *Jatropha curcas* is found in many Central and South American nations, its origin is still debated. Although it originated in Central America, it grows naturally in tropical regions worldwide (Table 1).

Table 2. Vernacular names of the botanical (Divakara et al., 2010)

Country/Language	**Vernaculars Names**
Hindi	Ratanjyot
English	Purging Nut
Indonesia	Jarak Budeg
Sanskrit	Parvataranda
Thailand	Sabudam
Portuguese	Purgueira

Portuguese traders introduced *Jatropha curcas*, an oil plant, to Asia and Africa. It may be found in practically all biogeographical zones in India, from the coastal regions to the outer Himalayan peaks, in wild, semi-wild, and cultivated conditions (Fresnedo-Ramírez, & Orozco-Ramírez, 2013). The genus name *Jatropha curcas* is derived from the Greek “Jatros” which means doctor and “trophe” which means food related to its medical use. *Jatropha* belongs to the Euphorbiaceae family, which is composed of approximately 175 species. The Vernacular names of the plant are as follows (Table 2). The plant or shrub is smooth, greyish bark and releases white latex when cut. It typically reaches a height of 3 to 5 meters, although, under favorable conditions, it can grow as tall as 8 to 10 meters.

Leaves

The plant features large, three- to five-lobed leaves that are green to pale green in color. The leaves are arranged alternately in opposite directions and follow a helical phyllotaxis pattern (Asseleih et al., 1989).

Figure 2. ***Jatropha curcas*** **plant (a) stem and leaves; (b) immature fruits; (c) ripen fruits; (d) mature fruits (e) various stages of fruit maturation**

Flowers

The petioles, which connect the leaves to the stem, range from 6 to 23 mm. Development of the inflorescence takes place in the leaf's axils. Female blooms develop singly and terminally and tend to be larger during warmer months. An imbalance in pistillate flower generation causes a larger percentage of female flowers when continuous growth occurs. Beekeeping practices can increase female bloom production, leading to higher seed yields (Kumar & Tewari, 2015).

Fruits

The shrub produces fruit during winter without leaves. If the soil remains moist and the temperature is favorable, multiple fruiting cycles can occur throughout the year. Each inflorescence on the plant produces a cluster of ten or more ovoid fruits (Heller, 1996). As the seeds mature and the fleshy outer covering (exocarp) dries a bivalved, three-valved cocci structure forms.

Seeds

After fertilization, the seeds mature in two to four months, as shown by the green capsule becoming yellow. The thin shells of the oblong, dark brown seeds resemble castor seeds (Foidl et al., 1996). The pictorial representation of Jatropha plant has been shown from its natural habitat (Figure 2).

Traditional uses

Recent research methodologies have included efforts to transform herbal remedies into high-quality, effective, and secure products for human use. The chemical formulas obtained from various plant components are the key to curing these ailments and diseases. The traditional use of Jatropha plant has been mentioned in Table 3.

Table 3. Traditional Uses of Jatropha plant

Plant parts	Region	Ethnomedicinal Uses	References
Fruit	India	Constipation, fracture, swelling, head-ache	Sharma et al., 2012
	Nigeria	Diabetes	Jain & Srivastava, 2005
Leaves	West Africa	Fever, convulsion, anthelmintic	Sarabia et al., 2022
	Nigeria	Diabetes	Gbolade, 2009
Root	India	Jaundice and liver troubles, Mouthwash fortoothache and bleeding gum, eczema, andringworm	Sarabia et al., 2022
Seed	Venezuela	Dysentery	Iwu,1993
	India	Stomach disorders	Abdelgadir & Staden, 2013
Bark	India	Diarrhea, dysentery	Borah et al., 2006
Oil	West Africa	Herpes, itch, and rubefacient	Rajendran et al., 2008
	India	Rheumatism	Heller, 1996
Latex	Columbia	Burns, hemorrhoids scabies, ulcers	Sarabia et al., 2022
Stem	India	Eczema, mouth ulcers, genital itching	Verma & Chauhan, 2007; Abdelgadir & Staden, 2013
	West Africa	Gout, paralysis, worm infection	Sarabia et al., 2022

Chemical Constituents

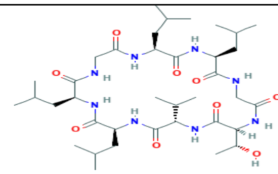
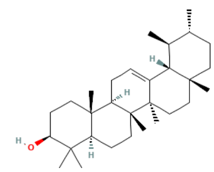
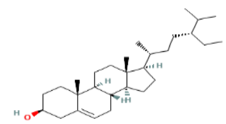
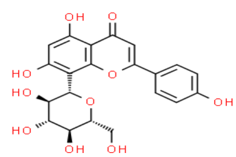
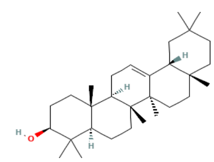
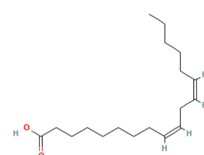
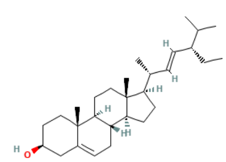
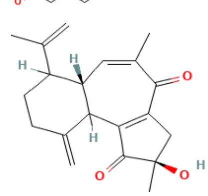
This plant offers a wide range of current and future uses, particularly in the medical sector. There are several medicinal uses for *Jatropha curcas*. The experts have examined and investigated numerous components of the Jatropha plant. Different parts of this plant are utilized to treat various diseases due to their chemical compositions. Table 4 and 5 list the various chemical constituents and their structures present in different parts of *Jatropha curcas.*

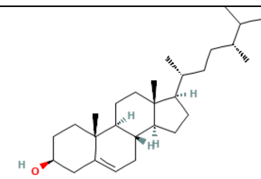
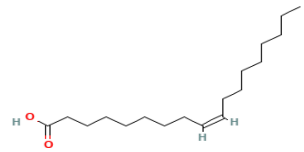
Table 4. Various Chemical Constituents are present in different plant parts of Jatropha

Plant Parts	Chemical Constituents	References
Kernel and oilcake	Saponins And Trypsin inhibitors	Islam et al., 2011
Seeds	Lectin, phorbol esters, phorbol acetate, and lipase	Prasad et al., 2012
Latex	Cyclic octapeptide Curcacycline A and Curcain (a protease)	Van den Berg et al.,1995
Aerial parts	Saponins, resorcylic acid, Amyrin, Sitosterol, Tannins and protocatechuic acid	Islam et al., 2011
Leaves	Apigenin, vitexin and isovitexin	Hufford & Oguntimein,

		1978; Mitra et al., 1970
Stem bark	Taraxerol, sitosterol and amyrin	Mitra et al., 1970
Root	Curculathyranes A and B, curcusones A-D, cou-marintomentin, diterpenoids jatrophol and jatropholone A and B, coumarino-lignan jatrophin, and taraxerol	Prasad et al., 2012

Table 5. Structure of some of the active compounds reported in *Jatropha curcas*

Chemical Constituents	MolecularFormulae	Structure
Curcacycline A	C37H66N8O9	
Alpha Amyrin	C30H50O	
Beta Sitosterol	C29H50O	
Vitexin	C21H20O10	
Beta Amyrin	C30H50O	
Linoleic Acid	C18H32O2	
Stigmasterol	C29H48O	
Curcusone D	C20H24O3	

Campesterol	$C_{28}H_{48}O$	
Oleic Acid	$C_{18}H_{34}O_2$	

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Pharmacological activities

Antiviral activity

An aqueous extract obtained from *Jatropha curcas* branches inhibits HIV cytotoxic effects. This extract also has negligible cytotoxicity (Muanza et al., 1995). The latex derived from *Jatropha curcas* inhibits the Watermelon mosaic virus (Kumar & Tewari, 2015).

Antidiarrheal activity

A study was done to find out how the alkaloid extract from *J. curcas* seeds affected intestinal motility. The study utilized an in vivo method to assess gastrointestinal motility in 50 rats. Two oral doses of the extract, 500 mg/kg and 1000 mg/kg were administered, along with 0.1 mL/10 g of activated carbon as a gastrointestinal marker. The research findings revealed that the alkaloid extract of *Jatropha curcas* reduced intestinal motility at 1000 mg/kg (Carrasco Rueda et al., 2013).

Anticancer activity

Researchers investigated the antiproliferative effects of *J. curcas* and *Jatropha gossypiifolia* on HeLa cancer cell lines. They also assessed cytotoxicity and antioxidant potential. Several studies have been conducted (Lahiri et al., 2016; Cavalcante et al., 2020). These results indicated that both species' ethanolic and methanolic extracts demonstrated promising anticarcinogenic properties. The findings suggest that these extracts hold potential as valuable candidates for further cancer treatment research.

Antibacterial activity

According to studies, when treated with chloroform, methanol, ethanol, and acetone extracts, the root bark of *J. curcas* showed inhibitory effects on the growth of both gram-positive bacteria Staphylococcus aureus) and gram-negative bacteria like Pseudomonas aeruginosa and Escherichia coli (Saadaoui et al., 2015; Kumar & Tewari, 2015).

Larvicidal and insecticidal activities

J. curcas extracts were tested for insecticidal and larvicidal abilities. The first investigation concentrated on the effectiveness of ethyl acetate and methanol extracts against *Bactrocera zonata* and *Bactrocera cucurbitae* larvae. Spraying the larvae with various quantities (200, 400, and 800 mg/L) combined with natural food resulted in a significant larvicidal impact, with the crude ethyl acetate extract displaying the greatest efficiency (Rampadarath et al., 2016). Several studies have examined *J. curcas* oil's effectiveness against the cabbage pest *Brevicoryne brassicae* (Valdez-Ramirez et al., 2023). The oil was shown to be quite effective, leading to noticeable aphid death during the first 24 and 48 hours after spraying. This was according to assessments of mortality 24-, 48-, and 72 hours post-treatment in a greenhouse.

Other important activities

Various investigations have been conducted on different aspects of *Jatropha* species, including its anti-HIV properties and acute and chronic toxicity assessment of *Jatropha curcas* detoxification (See et al., 2016; da Silva et al., 2015). The cytotoxicity of *Jatropha curcas* and its potential to inhibit the hemagglutinin protein of the influenza virus (Patil et al., 2013). Additionally, studies have explored the anthelmintic and anti-plasmodial activities of *Jatropha curcas* and its ameliorating effects (Mahyoub et al., 2015).

Commercial uses of *Jatropha curcas*

Raw materials for dye

J. curcas bark produces a deep blue dye used for dyeing cloth, fishing nets, and lines. This dye can be extracted from the leaves and young stems, concentrated into a yellowish syrup, or dried into a blackish-brown lumpy form. When applied to cotton, the dye imparts shades of tan and brown, exhibiting considerable colorfastness (Islam et al., 2011).

Soap making

The glycerin by-product resulting from the trans-esterification process can be employed to produce premium soap, or it can undergo refinement and be sold at various price points based on its purity. This refined glycerin finds application in a wide range of products, including cosmetics and toothpaste. The soap, known for its beneficial impact on the skin, is specifically marketed for medicinal purposes. Jatropha oil is widely used in soap production. According to IPGI data, pressing 12 kg of seeds yields 3 L of oil. This can be further converted into 28 soap bars weighing 170 g, totaling 4.76 kg. The estimated time required for this process is approximately 5 hours (Benge, 2006; Islam et al., 2011).

Fuel for cooking

Additionally, raw Jatropha oil can replace kerosene in lights and cooking stoves. However, modifications are required to consider its poor absorption capacity and high viscosity (Tomomatsu & Swallow, 2007). In addition to saving trees and lowering greenhouse gas emissions like CO and NO, utilizing plant oil for cooking has several advantages over conventional biomass. In addition, it improves health by lowering smoke inhalation. Jatropha oil may be used to make novel goods because of its thicker viscosity than kerosene, necessitating a certain burner type. The non-governmental group Kakute provided farmers in Zimbabwe's Mutoko district with "Kakute stoves," or cooking appliances that burn Jatropha oil, which was beneficial to the community (Van Eijck et al., 2011).

In place of fossil fuel diesel

Due to its biodegradability, non-toxicity, and ecologically favorable qualities, biodiesel fuel has gained significant popularity worldwide, resulting in fewer greenhouse gas (GHG) emissions. Adoption of biodiesel is also seen to be a successful way to reduce air pollution, such as smoke, particulate matter (PM), carbon monoxide (CO), sulfur, and polycyclic aromatic hydrocarbons (PAH) (Ong et al., 2011). Flashpoint, viscosity, cetane rating, and density are essential fuel properties when considering biodiesel for diesel engines (Patel et al., 2019). When evaluating fuel quality, the cetane number is very influential since it affects ignition and combustion in diesel engines. According to some sources, Jatropha has a cetane rating as high as 55, which is comparable to diesel. (Table 6). Therefore, any biodiesel that wishes to replace diesel must retain a higher cetane rating (Ramos et al., 2009).

Table 6. A comparison between vegetable oil and biodiesel specifications

Properties	Diesel	*Jatropha* Biodiesel	Palm Biodiesel	EN 14214	ASTM D6751
Flash point, °C	50-98	135	181	Min. 120	Min. 130
Density, kg/m³	816-840	862	879.3	860–900	860–900
Viscosity, mm²/s	2.5-5.7	4.8	4.9	3.5–5.0	1.9–6.0
Cetane number	45-55	57	52	Min. 51	Min. 47

(Che Hamzah et al., 2020)

The American Standard Specifications for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels (ASTM 6751) and the European Standard for Biodiesel (EN 14214) are the two biodiesel standards that must be followed when using vegetable-based biodiesel in practical applications.

Other significant uses

Jatropha oil serves multiple purposes, including leather softening and machinery lubrication. When seed cake is abundant, it can also be utilized as fuel for steam turbines, generating electricity. Besides its use in biodiesel production, Jatropha's bark contains tannin, and the flowers attract bees, making it suitable for honey production (Thomas et al., 2008).

CONCLUSION

With global warming and severe food security challenges for an expanding human population, directing our attention towards non-edible oil-bearing crops as biodiesel feedstock becomes crucial. *J. curcas* shows promising potential as a significant biodiesel feedstock in the future. *J. curcas* is a popular tree that grows quickly. It is a historically significant medicinal plant with several industrial uses. *J. curcas* has Antiviral, Anticancer, disinfectant/anti-parasitic, wound healing, insecticidal, and anti-diarrheal effects. Due to its minimal cytotoxicity and anti-tumour efficacy, *J. curcas* is being studied for its potential application as an anticancer agent. Curcin, Curcusone B, Curcain, and Curcacycline-A are the principal components. Seed oil phorbol esters have a wide range of biological effects. Nowadays, plants are utilized for a variety of industrial purposes, such as oil production, leather softening, and machinery lubrication. These features make this plant profitable and an alternate energy source for local and global communities. Jatropha biodiesel promotes eco-friendly growth with benefits for the economy and the environment, such as reduced pollution emissions, more rural jobs, a more secure energy supply, and less dependence on petroleum and coal. Several regions of the world have a very high level of interest in the plant. These regions are Central America, where it is native, and Mali, where it is found. There is still so much research work that has not been fully exploited and in the future, it is a promising crop for the modern world.

AUTHOR CONTRIBUTIONS

Namrata Jaspal and Deepika B. Prasher had drafted the manuscript, Munish Sharma and Rahul Sharma had done review of literature, technical check and revised the manuscript, Munish Sharma had the idea, approved the final version and supervised the work.

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COMPETING INTERESTS

The authors have declared that no conflict of interest exists.

ETHICS APPROVAL

Not applicable.

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