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A COMPREHENSIVE OVERVIEW ON *JATROPHA CURCAS* LINN.

Prathamesh R. Mundale * and Halima K. Malgundkar

Govindrao Nikam College of Pharmacy, Sawarde, University of Mumbai, Chiplun, Ratnagiri - 415606, Maharashtra, India.

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Correspondence to Author:
Prathamesh R. Mundale

Student,
Govindrao Nikam College of Pharmacy, Sawarde, University of Mumbai, Chiplun, Ratnagiri - 415606, Maharashtra, India.

E-mail: prathameshmundale@gmail.com

ABSTRACT: *Jatropha curcas*, a plant species belonging to the Euphorbiaceae family, has emerged as a promising candidate for sustainable energy production. Its resilience to harsh environmental conditions, adaptability to marginal lands, and ability to produce high yields of oil-rich seeds make it a valuable resource for addressing the global energy crisis. The oil extracted from jatropha seeds can be converted into biodiesel, a renewable fuel alternative to fossil fuels. Biodiesel produced from jatropha offers several advantages, including reduced greenhouse gas emissions, improved air quality, and reduced dependence on foreign oil. This makes it a significant contributor to efforts to mitigate climate change and enhance energy security. Beyond biofuel, jatropha oil has a wide range of industrial and agricultural applications. It can be used in the production of soaps, detergents, lubricants, and even as a component in certain types of plastics. Additionally, jatropha can contribute to sustainable agriculture by improving soil fertility and providing a source of organic fertilizer. While jatropha offers numerous benefits, its cultivation and utilization are not without challenges. Issues such as seed dormancy, low germination rates, and susceptibility to pests and diseases need to be addressed to ensure its successful adoption. However, with appropriate research and development, these challenges can be overcome. Overall, *Jatropha curcas* represents a promising solution to the growing energy crisis and the need for sustainable resource management. Its potential to provide both renewable energy and valuable industrial products makes it a valuable asset in the transition to a more sustainable future.

INTRODUCTION: *Jatropha curcas* Linn., commonly known as the physic nut, belongs to the Euphorbiaceae family. This drought-resistant plant **Fig. 1** thrives in marginal lands with varying rainfall levels and can be cultivated as a commercial crop. Jatropha is easy to propagate and requires minimal care, growing wild in many regions and even in infertile soils. The plant has a long lifespan, producing seeds for up to 50 years.

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FIG. 1: *JATROPHA CURCAS* YOUNG PLANT

The oil content in jatropha seeds can reach up to 47%, with an average range of 37-40%. This makes it an excellent candidate for future biodiesel production. Beyond biodiesel, jatropha oil has various applications, including soap making,

cleaning, dyeing fabrics, medicinal uses, organic fertilizers, and as an antidote for snake bites. It can also be used to soften leather and lubricate machinery. Each part of the jatropha plant leaves, flowers, fruits, and seeds has its own unique uses, making it a highly versatile and beneficial plant. Taxonomy of *Jatropha curcas* L. is given in **Table 1** [1].

TABLE 1: TAXONOMY OF *JATROPHA CURCAS* PLANT

Taxonomy	
Kingdom	Plantae
Division	Embryophyta
Class	Spermatopsida
Order	Malpighiales
Family	Euphorbiaceae
Genus	Jatropha
Species	Jatropha curcus
Scientificname	*Jatropha curcas Linnaeus*
Commonname	Physic nut, Babados nut, Purging nut

Botanical Profile: The physic nut (*Jatropha curcas*) is a drought-resistant species commonly cultivated in tropical regions as a living fence. Although various parts of the plant are used in traditional medicine, its seeds **Fig 2** are toxic to humans and many animals. Historically, *Jatropha* seeds were economically significant in Cape Verde, where they were exported for oil extraction and soap production, but current global production is minimal.

FIG. 2: *JATROPHA CURCUS* SEEDLINGS

Botanically, the physic nut is a small tree or large shrub that can grow up to 5 meters in height. The plant displays articulated growth with distinct morphological changes at each increment, and its dormancy is influenced by variations in rainfall and temperature or light. It has five roots emerging from seedlings, with one central and four peripheral roots, while vegetatively propagated plants typically do not develop a tap root. The leaves are shallowly lobed, ranging from 6 to 15 cm in length and width, and are alternately arranged. Its inflorescences, which are complex and terminally located, are botanically described as a cyme. The plant is monoecious, with unisexual flowers, although hermaphrodite flowers occasionally occur. The androecium consists of ten stamens in two distinct whorls, while the gynoecium has three connate styles forming bifurcate stigmas **Fig. 3.**

Pollination is primarily by insects, and *Jatropha* is believed to be pollinated by moths due to its sweet perfume at night and other flower characteristics. In the absence of insects, hand pollination is required for seed production. Occasionally, self-pollination occurs in rare hermaphrodite flowers. The plant forms a trilocular ellipsoidal fruit after pollination, with black seeds about 2 cm long and 1 cm thick. *Jatropha curcas* is a diploid species with 22 chromosomes (2n = 22) [2].

FIG. 3: *JATROPHA CURCUS* FLOWER CLUSTER

Propagation: *Jatropha curcas* can be propagated through cuttings or seeds. Cuttings are typically prepared from one-year-old terminal branches measuring 25-30 centimetres. To enhance plant growth and fungal symbiosis, especially in infertile soils, it's beneficial to inoculate cuttings with mycorrhizal fungi before planting them in a nursery. Studies have shown that endomycorrhizal fungi are commonly associated with Jatropha in its natural habitat.

Cuttings treated with 10-100 mg/l of indole-3-butyric acid (IBA) for 24 hours have a 100% rooting rate after 45 days. IBA is more effective than 1-naphtaleneacetic acid (NAA) and results in

higher cutting survival rates (>90%), increased leaf production, and earlier flowering. Healthier cuttings are selected for field acclimatization. While cutting propagation allows for the cultivation of elite accessions, large-scale plantations are typically achieved through sowing. Seeds are pre-soaked in water for 24 hours and germinate within 5-10 days at 27-30 degrees Celsius with high humidity. Cuttings and seedlings are grown in nurseries for two months before being transplanted to the field at the beginning of the rainy season. During the dry season, Jatropha plants become dormant and lose their leaves [3].

Flowering and Pollination: *Jatropha curcas* is a monoecious plant, meaning it has separate male and female flowers on the same plant. Its inflorescences, located at the ends of branches, contain both types of flowers. The central female flower is surrounded by several smaller male flowers. While *Jatropha curcas* typically produces unisexual flowers, some inflorescences may have a few male flowers. All flowers, both male and female, usually open simultaneously, allowing for cross-pollination between flowers from the same or different plants. Female flowers and buds are slightly larger than male flowers. Adequate soil moisture and appropriate temperatures are conducive to *Jatropha curcas* producing two crops per year. In Egyptian conditions, *Jatropha curcas* blooms twice annually, once in April and again in December [4].

Fruiting and Seed Maturity: Jatropha fruits, which measure approximately 2.5 cm in length, contain three black seeds. These fruits reach full maturity about 90 days after pollination. The ripening process can be divided into three stages:

Green Stage: This occurs 30-45 days after pollination.

Yellow Stage: Fruits mature during this stage, which lasts from 45 to 60 days.

Ripe Stage: Fruits begin to ripen approximately 60 days after pollination [5].

FIG. 4: *JATROPHA CURCUS* FRUIT (IMMATURE)

FIG. 5: *JATROPHA CURCUS* FRUIT (MATURE)

The physical characteristics of *J. curcas* fruits change throughout their six maturation stages is given in **Table 2**. The fruits reach their maximum length at stage 2 and their maximum diameter at stage 3. After these stages, both the length and diameter decrease as the fruits lose water during the maturation process. The length and diameter range from 33.0 mm and 28.3 mm in stage 1 fruits to 27.2 mm and 21.4 mm in stage 6 fruits, respectively [6].

TABLE 2: LENGTH AND DIAMETER OF FRUITS AND SEEDS OF *JATROPHA CURCAS L.* DEPENDING ON THE MATURATION STAGES

Maturation Stage	Fruit		Seed	
	Length	Diameter	Length	Diameter
	---(mm)---			
1	33.01a	28.26 a	20.72 a	8.92 a
2	32.48ab	28.06 a	20.95 a	8.87 a
3	31.96 bc	27.30 a	20.59 a	8.85 a

4	31.11 c	26.31 b	19.95 b	8.86 a
5	28.44 d	24.14 c	19.57 b	8.74 a
6	27.16 e	21.39 d	18.89 c	8.75 a
MSD	0.96	0.98	0.55	0.36
CV (%)	1.39	1.67	1.21	1.79

Soil and Climate: *Jatropha curcas* thrives in diverse regions, with cultivation limits between 30°N and 35°S and at altitudes up to 500 meters above sea level. It requires temperatures ranging from 20°C to 28°C, but extremely hot climates can hinder flower fertilization and overall yields. Jatropha is not tolerant of cold weather.

Jatropha curcas is well-suited for arid and semi-arid environments. It grows optimally in well-aerated sandy loam soil with a depth of at least 45 cm. While it can tolerate alkaline soils with a pH of 6.0 to 8.5, Jatropha requires good drainage in heavy clay soils due to its intolerance of waterlogged conditions. Although it can grow and survive on marginal lands and with poor-quality water, these conditions often result in lower yields [7].

MATERIALS AND METHODOLOGY:

Extraction from Seeds Kernels:

Solvent Extraction Technique: The seeds of *Jatropha curcas* L. were first cracked open and the shells were carefully removed. The resulting kernels, weighing 1 gram, were ground using a mortar and pestle. To extract the oil, various organic solvents (20 ml each) including petroleum ether, hexane, and isopropanol were used. The extraction process involved different techniques such as filtration, centrifugation, and the use of a separating funnel to separate the oil from the solid residues and solvents. Once the extraction was complete, the oil was stored in a freezer at -20°C for future physicochemical analysis.

Aqueous Enzymatic Oil Extraction (AEOE) from Seed Kernels: Five grams of Jatropha seeds were soaked in water for 2 hours. After soaking, the seeds were ground into a thick paste using a mortar and pestle, without adding extra water. This paste was then mixed with distilled water at a 1:2 (w/v) ratio of paste to water and stirred gently using a magnetic stirrer. To facilitate the process, 250 mg of cellulase (Himedia, 15 FTU/ml) was added, and the pH of the mixture was adjusted to 4 with either 0.5 N HCl or NaOH. The enzyme solution was incubated overnight at 40°C with continuous shaking at 100 rpm. After incubation, the upper oil phase was separated by centrifugation at 10,000 x g for 20 minutes. A control extraction, referred to as aqueous oil extraction (AOE), was performed under the same conditions but without the addition of any enzyme.

Soxhlet Extraction: Three grams of seed kernels were ground using a mechanical method and then defatted using a Soxhlet extractor. The extraction process was conducted with three different solvents hexane, isopropanol, and petroleum ether for a duration of 6 hours. After extraction, the solvents were removed through vacuum evaporation followed by heating in a drying oven at 50°C. The amount of oil recovered was expressed as a percentage of the total oil content in the *Jatropha curcas* seed kernels. Each extraction was performed in triplicate, and the final result is presented as the average of these measurements [8].

Extraction from Leaves:

Soxhlet Extraction: Fresh, mature, healthy leaves from fully grown *Jatropha curcas* Linn. plants were collected and identified. The leaves were air-dried in the shade and then ground into a fine powder using a mixer grinder. Approximately 30 grams of this powdered material were subjected to extraction using a Soxhlet apparatus with 600 mL of each solvent: methanol and water. Methanol of analytical grade was used for the extraction. The extracts were filtered through Whatman No. 1 filter paper, and the resulting aqueous and methanol filtrates were concentrated to dryness using a rotary evaporator to remove the solvents. The residues, which were greenish and brown in color, were then stored in a refrigerator until needed [9].

Cold Maceration: Fresh *Jatropha curcas* leaves were gathered and identified for the study. The extraction was performed using the cold maceration technique. The leaves were first air-dried, then cut into small pieces and ground into a coarse powder with particles roughly 1 mm in diameter. Six hundred grams of this powdered material were subjected to extraction with 80% methanol over a

period of 48 hours, with the mixture being shaken intermittently every 2 hours. After extraction, the mixture was filtered through Whatman No. 1 filter paper. The filtrate was then concentrated under reduced pressure using a rotary evaporator at 40°C and 210 millibar to remove the methanol [10].

By Percolation: A 20 g sample of powdered leaves was measured and percolated in 200 ml of 96% ethanol in a 500 ml conical flask. The flask was manually agitated intermittently over a 24-hour period to enhance extraction. Afterward, the mixture was filtered through Whatman No. 1 filter paper, and the resulting filtrate was collected in a clean beaker. The ethanol in the filtrate was evaporated to dryness using a steam bath maintained at 80°C [2].

Extraction from the Fruits of *Jatropha curcas*: *Jatropha curcas* fruits were harvested 8 weeks after the development of pinhead-sized fruits. To remove dust and impurities, the collected fruits were thoroughly washed with distilled water. They were then air-dried on a plastic tray at room temperature for 3 days. Subsequently, the fruits were oven-dried at 50°C for 5 to 7 days to achieve a final moisture content of 12%, as confirmed using a moisture analyzer (MF-50, US). The extraction of plant materials followed a modified version of the methods described by Okoh *et al.* (2009) and Obafemi *et al.* (2006). The fruits were manually separated into pulp and seeds using a knife. The whole fruits, pulp, and seeds were ground separately using a Polymix grinder (CZ 13, Cullaati MFC grinder, Netherlands). For the extraction process, 20 g of each ground sample (whole fruit, pulp, and seeds) were placed into separate 250 ml Erlenmeyer flasks, to which 120 ml of methanol was added as the solvent. The flasks were sealed with aluminum foil and parafilm to minimize solvent evaporation. The mixtures were left to stand for 7 days at room temperature, after which they were filtered using 90 mm filter paper (Toyo Roshi Kaisha, Ltd., Japan). The filtrates were then concentrated using a rotary evaporator under reduced pressure to remove the methanol solvent [11].

Preliminary Phytochemical Screening: To determine the chemical composition of plant extracts, standard tests were conducted following established methods. These tests screened for various compounds, including alkaloids, flavonoids, cardiac glycosides, saponin glycosides, tannins, steroids and triterpenoids given in **Table 3, 4, 5, 6, 7** and **8** respectively.

Test for Alkaloid:

TABLE 3: TEST FOR ALKALOIDS

Test	Observation	Inference
Mayer's Test–One ml of Mayer's reagent was added to different extracts.	Formation of a cream or white precipitate.	Alkaloid is present.
Wagner's Test–One ml of Wagner's reagent was added to different extracts.	Formation of a brown or reddish-brown precipitate.	Alkaloid is present.
Dragendroff's Test–One ml of Dragendroff's reagent was added to different extracts.	Formation of an orange or reddish-brown precipitate.	Alkaloid is present.

Test for Flavonoid:

TABLE 4: TEST FOR FLAVONOIDS

Test	Observation	Inference
Shinoda Test –Add a small piece of magnesium ribbon to the extract and few drops of concentrated hydrochloric acid (HCl)	Formation of a pink, red, or orange color	Flavonoid is Present
Ferric Chloride Test –Add few drops of neutral ferric chloride solution to the extract.	Formation of a blackish-red color	Flavonoid is Present
Lead Acetate Test – Add few drops of lead acetate solution to the extract.	Formation of a yellow precipitate	Flavonoid is Present
Alkaline Reagent Test –Add few drops of sodium hydroxide (NaOH) solution and dilute hydrochloric acid (HCl)	Formation of an intense yellow color and becomes colourless upon adding dilute HCl	Flavonoid is Present

Test for Cardiac Glycosides:

TABLE 5: TEST FOR CARDIAC GLYCOSIDES

Test	Observation	Inference
Keller-Killani Test (Test for deoxy sugars) -The drug was extracted using chloroform, then dried. A solution of glacial acetic acid containing a small amount of ferric chloride was added to the dried extract. This mixture was then placed in a test tube and concentrated sulfuric acid was carefully poured down the side.	Appearance of blue colour of acetic acid layer.	Cardiac Glycoside is Present.

Test for Saponin Glycosides:

TABLE 6: TEST FOR SAPONIN GLYCOSIDES

Test	Observation	Inference
Froth formation Test–Dissolve small amount extract in distilled waterand shake it.	Formation of stable froth	Saponin Glycoside is Present.

Test for Tannins:

TABLE 7: TEST FOR TANNINS

Test	Observation	Inference
Ferric Chloride ($FeCl_3$) Test – Add few drops of ferric chloride ($FeCl_3$) solution to the extract.	Formation of blue-black or green-black color.	Tannin is Present.
Gelatin Test - Add a 1% solution of gelatin containing 10% sodium chloride to the extract.	Formation of a white precipitate.	Tannin is Present.

Test for Steroids and Triterpenoids:

TABLE 8: TEST FOR STEROIDS AND TRITERPENOIDS

Test	Observation	Inference
Salkowski Test – Extract is treated with few drops of concentrated sulfuric acid (H_2SO_4).	Appearance of red and yellow colour at the lower layer.	Steroids and Triterpenoids is present.

The preliminary phytochemical analysis of the alcoholic extract of *Jatropha curcas* Linn identified the presence of alkaloids, phenolic compounds, flavonoids, saponins, steroids, tannins, cardiac glycosides, and terpenoids using standard techniques [12, 13].

Evaluation Techniques:

High Performance Liquid Chromatography (HTLC): The condensed extracts were screened for secondary metabolites using High-Performance Thin-Layer Chromatography (HPTLC). HPTLC was conducted following a standard protocol. The chromatography was carried out on pre-activated silica gel plates (MERCK 60F254) at 110°C. The mobile phase used was a mixture of toluene, ethyl acetate, and formic acid in a 7:2:1 ratio.

Standard compounds and sample extracts (5 µL each) were applied to the plates as 8 mm-wide bands using an automated CAMAG Linomat IV applicator. The plates were then developed up to a height of 10 cm under laboratory conditions, maintaining a temperature between 25–30°C and a relative humidity of 40–50% in a controlled developing chamber. After development, the plates were dried with an air stream and subsequently sprayed with a sulphuric acid: ethanol solution (5:95 v/v). The plates were further dried and then heated at 110°C for 25 minutes to visualize the spots.

For quantitative analysis, the spots on the developed plates were scanned using a CAMAG TLC scanner at wavelengths of 254 and 366 nm [9].

Thin Layer Chromatography: Thin Layer Chromatography (TLC) was utilized to separate the various constituents of the *Jatropha curcas* extract into distinct spots on a chromatographic plate.

The chromatograms were prepared on microscope slides, allowed to dry, and then visually inspected to identify the different components present in the plant extract. A solvent mixture of hexane, chloroform and few drops of acetic acid in a 8:2 ratio was used for developing the different extracts. The retention factor was calculated using following equation [12]:

R_f = Distance travelled by sample (cm) / Distance travelled by solvent (cm)

Gas Chromatography – Mass Spectroscopy (GC - MC): The chemical composition of the extracts was characterized using Gas Chromatography-Mass Spectrometry (GC-MS) following the method of Hossain and Rahman (2011). A Shimadzu QP2010PLUS GC-MS system was employed for the analysis. For each extract, 6 microliters were injected onto a BPX-5 SGE ultra-low-bleed capillary column (30 m length × 0.25 mm internal diameter × 0.25 µm film thickness), using a splitless injection with a purge time of 1.0 minute. Helium was used as the carrier gas at a flow rate of 1 mL per minute.

The column temperature was initially set at 50°C for 3 minutes, then increased at a rate of 5°C per minute up to 80°C, and subsequently raised at a rate of 10°C per minute up to a maximum of 340°C. The inlet temperature was maintained at 250°C, while the detector temperature was set to 340°C, with a solvent delay of 4 minutes. Peaks were identified by matching the mass spectra with the National Institute of Standards and Technology (NIST 08 and NIST 08s) library and cross-referencing with published data [14].

Antioxidant Activity of *Jatropha curcas* Extract: A solution containing 0.05 mg/ml of DPPH (1,1-diphenyl picryl hydrazyl) in methanol was prepared which absorbs the light at a wavelength of 517 nm. The dried plant extract (from both leaves and seeds) was dissolved in methanol to create a solution with a concentration of 1 mg/ml. Then, 0.1 ml of this extract solution were added to 1.4 ml of the DPPH solution. The mixture was allowed to sit at room temperature for 5 minutes. Finally, the absorbance of the solution at 517 nm was measured. The antioxidant activity of the extract was determined by measuring its ability to neutralize DPPH radicals. This was expressed as the percentage of DPPH radicals that were scavenged.

Antioxidant Activity (%) A0-A1 / A0 × 100

Were, A0: Absorbance of control, A1: Absorbance of extract [8].

Antibacterial Activity of *J. curcas* Extract: The antibacterial activity was evaluated using two strains of Gram-positive bacteria, *Bacillus spp***.** and *Staphylococcus aureus*, as well as two strains of Gram-negative bacteria, *Escherichia coli* and *Pseudomonas aeruginosa.*

To prepare agar plates, start by dissolving the appropriate amount of each agar medium in 100 ml of distilled water. For MacConkey's agar, use 5.53 grams; for Cetrimide agar, use 4.67 grams; for Vogel Johanson agar, use 6.1 grams; and for Nutrient agar, use 2.8 grams. Mix each medium thoroughly in separate conical flasks and sterilize them in an autoclave at 121°C and 15 lbs pressure for 15 minutes. Once sterilized, pour the media into sterilized plates before they solidify. For spreading and well preparation, inoculate the bacteria into saline water and spread the suspension on the agar plates using a sterile glass spreader. Create wells in the agar using a cork borer and add the plant extract into these wells under aseptic conditions. Finally, incubate the plates at 37°C for 48 hours. After incubation, observe and measure the inhibition zones in mm [2].

Medicinal Uses of *Jatropha curcas* Plant:

TABLE 9: MEDICINAL USES OF *JATROPHA CURCAS* PLANT

Category	Details
Traditional Uses	
Seeds, Leaves, and Bark	Used fresh or as a decoction for various ailments.
Oil	Acts as a strong purgative, treats skin diseases, and soothes rheumatic pain.
Leaf Decoction	Used for coughs and as an antiseptic post-birth.
Branches	Used as chewing sticks in Nigeria.
Sap	Stops bleeding from wounds.
Scientific Findings	
Curcain	A proteolytic enzyme from latex with wound-healing properties.
Antimicrobial Properties	Effective against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Streptococcus pyogenes*, and *Candida albicans*.
Blood Coagulation	Latex has coagulating effects on blood plasma.

Pregnancy Termination	Extracts from fruits showed embryotoxic effects in rats.
HIV Protection	Methanol extract of leaves offers moderate protection for cultured human lymphoblastoid cells against HIV.
Cardiovascular Action	Leaf extract shows potential as a beta-blocker in guinea pig.

The physic nut plant is a traditional remedy with applications in both human and veterinary medicine. Various parts of the plant, including seeds, leaves and bark, are used in decoctions or fresh form to treat a range of ailments. The plant's oil is known for its purgative properties and is also employed for skin diseases and pain relief, such as rheumatism. Leaves are used in decoctions to soothe coughs and as an antiseptic after childbirth. In Nigeria, branches are chewed as a dental hygiene aid. The sap from the stem is used to stop bleeding from wounds.

Scientific research has supported many of these traditional uses. For instance, studies have shown that curcain, a proteolytic enzyme isolated from the latex, promotes wound healing. The latex also exhibits antimicrobial activity against several bacteria like *Staphylococcus aureus*, *E. coli*, and *Klebsiella pneumoniae*, and fungi like *Candida albicans*. Additionally, the latex has been found to coagulate blood plasma. Other traditional uses documented in the literature include pregnancy termination effects in rats, protection against human immunodeficiency virus (HIV) in human cells, and potential cardiovascular benefits [15].

Some Common Uses of *Jatropha curcas* Plant Fig.:

1. In recent decades, the primary use of Jatropha has been to produce biofuel or biodiesel from its seeds [16].
2. The press cake from jatropha seeds is considered as a biomass feedstock for generating energy or biogas [4].
3. Powdered seed coats can serve as effective adsorbents for removing heavy metals from wastewater [17].
4. Jatropha trees are often used as hedges because animals find them unpalatable [18].

   Jatropha curcas is utilized to prevent soil erosion and combat desertification [4].

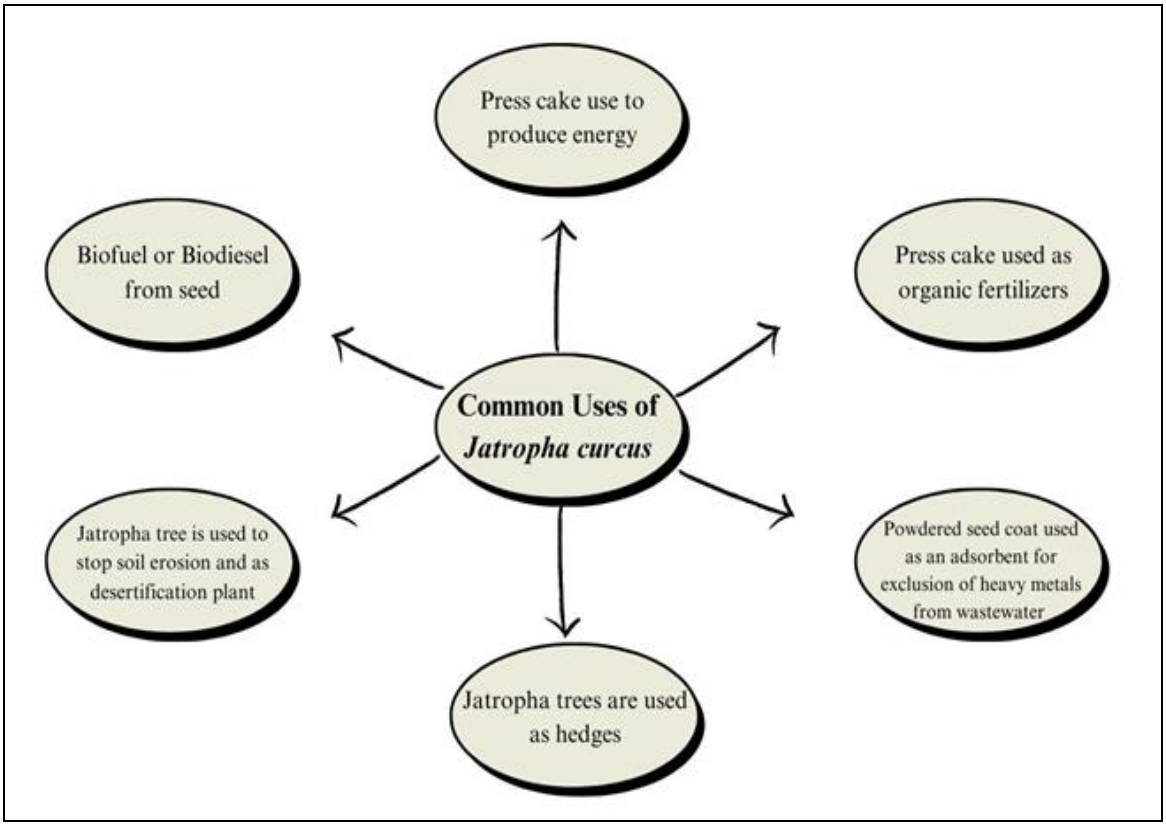

FIG. 6: COMMON USES OF *JATROPHA CURCUS*

Industrial Applications: Sustainable biomass energy offers a potential solution to the rising costs and environmental impacts of fossil fuels. Beyond its primary use as a fuel, plant biomass can generate valuable by products with diverse applications. The specific types of coproducts produced depend on factors such as the biofuel production method, coproduct recovery processes, and the source of the biomass itself.

Biofuel: *Jatropha curcas* is a promising source of biofuel and a valuable energy crop. Its seeds can be processed to produce both biofuel and biogas. The remaining seed cake can be further utilized for biogas production through anaerobic fermentation. Jatropha oil is suitable for industrial applications and as an energy source. Given its potential as a biofuel feedstock, jatropha has attracted significant research interest.

Biolubricant: A study compared the performance of a biolubricant made from jatropha oil to a conventional lubricant. The biolubricant was blended with SAE 40 lubricant at various concentrations (0%, 20%, 30%, 40%, and 50%). Aluminum pins and cast-iron discs were lubricated with these blends and tested for wear and temperature using a viscometer and multi-oil analyzer. Results indicated that a 10% concentration of jatropha oil in the biolubricant provided the lowest wear and generated the least heat. Increasing the jatropha oil concentration beyond 10% led to a significant increase in both wear and operating temperature.

Transformer Oil: *Jatropha curcas* oil has been shown to meet ASTM D standards for transformer oils. Its refined form can be used as a biodegradable and environmentally friendly alternative to conventional transformer oils, especially in areas where spills or leaks could harm marine life. The oil's low acid content contributes to its safety and sustainability.

Medicine and Cosmetics: Jatropha-based products, including seedlings, cuttings, seeds, and oil, are primarily traded within a limited network of collectors, extractors, and soap makers. The simple process of adding sodium hydroxide (caustic soda) to jatropha oil has made soap making a viable rural enterprise in many developing countries. Jatropha soap is valued for its medicinal properties, especially for treating skin conditions. The production process is efficient, with 4.7 kilograms of soap produced from 13 litters of oil in just five hours. The primary consumers of jatropha soap are individuals with skin diseases or allergies to traditional toilet and perfumed soaps.

Binderless Particle Board, Pulping and Paper Making Industries: Pulp and paper industries are essential components of both developed and developing economies. *Jatropha curcas* is a promising source of papermaking fibre due to its high content of lignin and other extractives. The presence of diagnostic monomers within *Jatropha curcas* confirms the existence of lignin. Lignin, a by-product of pulp and paper production, is a valuable resource for the papermaking and binderless particle board industries.

Biodiesel: *Jatropha curcas* is a promising source of non-edible biodiesel. The oil extracted from *jatropha curcas* seeds has favourable physicochemical properties, primarily consisting of monounsaturated triglycerides (OLL, POL, SLL, PLL, OOL, OOO, and POP). With an unsaturated fat content of 80.42%, *Jatropha curcas* oil is classified as an unsaturated oil suitable for both biodiesel production and industrial applications. Additionally, the *jatropha curcas* seed cake can be used to generate biogas with a high methane content through anaerobic fermentation and gasification.

Fertilizer: *Jatropha curcas* seed cake and other by-products, such as fruit coats and seed hulls, can be effectively used as organic fertilizers. Experiments have demonstrated that applying jatropha cake to jatropha plantations significantly boosts yields. Seed yields increased notably with increasing cake applications, reaching a maximum of 3 tonnes per hectare. These promising results suggest that jatropha cake can serve as a nutrient-rich fertilizer for jatropha plantations, improving soil fertility and increasing productivity, especially in wastelands.

Surface Coating: The unsaturated triglycerides in *jatropha curcas* seed oil significantly enhanced the scratch resistance, gloss, and hardness of EJO oligomer green coatings.

This suggests that jatropha seed oil-based resins could be a promising alternative to traditional resins in surface coatings, especially in overprint varnish applications, offering an environmentally friendly solution [19].

Current Progress of *Jatropha curcas*: The global energy crisis and growing environmental concerns have spurred interest in sustainable energy sources. Biodiesel, a renewable liquid fuel derived from plant oils, offers a promising alternative to traditional fossil fuels. It can be used in existing diesel engines without modifications, reducing harmful emissions and mitigating the impact of climate change.

The production of biodiesel involves a chemical process called transesterification, which converts plant oils into methyl esters. Methanol, a common solvent, is used in the presence of a catalyst to break down the triglycerides in the oil. Sodium hydroxide and potassium hydroxide are popular catalysts due to their efficiency and cost-effectiveness.

One promising feedstock for biodiesel production is *Jatropha curcas*, a tropical plant that can thrive in various climates. Its oil can be easily converted into biodiesel that meets international standards, while the remaining plant material can be used for fertilizer and biogas production. Additionally, Jatropha plants can help prevent soil erosion and reclaim degraded land.

As the world continues to search for sustainable energy solutions, biodiesel offers a viable option that can contribute to a cleaner and more environmentally friendly future [18].

CONCLUSION: *Jatropha curcas* (family - Euphorbiaceae) emerges as a versatile and sustainable plant with a wide range of applications. Its potential as a source of biodiesel, coupled with its resilience and adaptability to challenging environments, makes it a promising candidate for addressing energy and environmental concerns.

Jatropha oil offers a renewable and sustainable alternative to fossil fuels, with its high oil content and favourable physicochemical properties. The plant's ability to thrive in marginal lands, combat soil erosion, and enhance soil fertility contributes to sustainable agriculture and environmental conservation. Beyond biodiesel, Jatropha has potential applications in various industries, including medicine, cosmetics, pharmaceuticals, and materials science. The cultivation and processing of Jatropha can provide economic benefits to rural communities, especially in regions with limited agricultural resources.

While Jatropha holds significant promise, further research and development are necessary to address challenges such as low yields in certain regions, seed dormancy issues, and the need for efficient extraction and processing technologies. By overcoming these hurdles, Jatropha can play a vital role in transitioning towards a more sustainable and energy-efficient future.

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