



# Jatropha and Its Chemical Constituents, Uses and Properties

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## ABSTRACT

*Jatropha* is a genus of flowering plants in the spurge family, Euphorbiaceae. The name is derived from the Greek words *ιατρός* (*iatros*), meaning "physician", and *τροφή* (*trophe*), meaning "nutrition", hence the common name physic nut. Another common name is nettlespurge.<sup>[2]</sup> It contains approximately 170 species of succulent plants, shrubs and trees (some are deciduous, like *Jatropha curcas*). Most of these are native to the Americas, with 66 species found in the Old World.<sup>[3]</sup> Plants produce separate male and female flowers. As with many members of the family Euphorbiaceae, *Jatropha* contains compounds that are highly toxic. *Jatropha* species have traditionally been used in basketmaking, tanning and dye production. In the 2000s, one species, *Jatropha curcas*, generated interest as an oil crop for biodiesel production and also medicinal importance when used as lamp oil; native Mexicans in the Veracruz area developed by selective breeding a *Jatropha curcas* variant lacking the toxic compounds, yielding a better income when used as source for biodiesel, because of its edible byproduct. Toxicity may return if edible *Jatropha* is pollinated by toxic types.

**Keywords:** *Jatropha*, chemical, uses, types, constituents, euphorbiaceae, succulent, biodiesel, toxicity, pollinated

## 1. INTRODUCTION

The stems of haat (*Jatropha cuneata*) are used for basketmaking by the Seri people in Sonora, Mexico. The stems are roasted, split and soaked through an elaborate process. The reddish dye that is often used is made from the root of another plant species, *Krameria grayi*. Spicy jatropha (*J. integerrima*) is cultivated as an ornamental in the tropics for its continuously blooming crimson flowers. Buddha belly plant (*J. podagrica*) was used to tan leather and produce a red dye in Mexico and the southwestern United States. It is also used as a house plant.

The oil from *Jatropha curcas* is mainly converted into biodiesel for use in diesel engines.<sup>[4]</sup> The cake

resulting from oil extraction, a protein-rich product, can be used for fish or animal feed (if detoxified). It is also a biomass feedstock to power electricity plants or to produce biogas, and a high-quality organic fertilizer.<sup>[5]</sup>

In 2007, Goldman Sachs cited *Jatropha curcas* as one of the best candidates for future biodiesel production.<sup>[6]</sup> It is resistant to drought and pests, and produces seeds containing 27-40% oil,<sup>[7]</sup> averaging 34.4%.<sup>[8]</sup> The remaining press cake of *jatropha* seeds after oil extraction could also be considered for energy production.<sup>[9]</sup> However, despite their abundance and use as oil and reclamation plants, none of the *Jatropha* species have been properly domesticated and, as a result, their

productivity is variable, and the long-term impact of their large-scale use on soil quality and the environment is unknown.<sup>[10]</sup> 2009 research found that *Jatropha* biodiesel production requires significantly more water than other common biofuel crops, and that initial yield estimates were high.<sup>[11]</sup> Earlier, higher estimates from Worldwatch Institute had suggested that 1 acre of cultivation could yield 202 gallons (4.8 barrels) of biodiesel.<sup>[12]</sup>

*Jatropha curcas* is also being studied for use as a carbon sequestration plant in arid regions.<sup>[13]</sup>

Much like other members of the family Euphorbiaceae, members of the genus *Jatropha* contain several toxic compounds. The seeds of *Jatropha curcas* contain the highly poisonous toxin curcin, a lectin dimer. They also contain carcinogenic phorbol.<sup>[14]</sup> Despite this, the seeds are occasionally eaten after roasting, which reduces some of the toxicity. Its sap is a skin irritant, and ingesting as few as three untreated seeds can be fatal to humans. In 2005, Western Australia banned *Jatropha gossypifolia* as invasive and highly toxic to people and animals.<sup>[15]</sup> It continues to be used as a medicine in certain geographic regions; however one study found the dried leaf to have no anti-fungal activity.<sup>[16]</sup>

## 2. DISCUSSION

*Jatropha curcas* is a species of flowering plant in the spurge family, Euphorbiaceae, that is native to the American tropics, most likely Mexico and Central America.<sup>[2]</sup> It is originally native to the tropical areas of the Americas from Mexico to Argentina, and has been spread throughout the world in tropical and subtropical regions around the world, becoming naturalized or invasive in many areas.<sup>[3]</sup> The specific epithet, "curcas", was first used by Portuguese doctor Garcia de Orta more than 400 years ago.<sup>[4]</sup> Common names in English include physic nut, Barbados nut, poison nut, bubble bush or purging nut.<sup>[3]</sup> In parts of Africa and areas in Asia such as India it is often known as "castor oil plant" or "hedge castor oil plant",<sup>[3]</sup> but it is not the same as the usual castor oil plant, *Ricinus communis* (they are in the same family but different subfamilies).

*J. curcas* is a semi-evergreen shrub or small tree, reaching a height of 6 metres (20 feet) or more.<sup>[2]</sup> It is

resistant to a high degree of aridity, allowing it to grow in deserts.<sup>[5][6]</sup> It contains phorbol esters, which are considered toxic.<sup>[7]</sup> However, edible (non-toxic) varieties native to Mexico also exist, known by the local population as piñón manso, xuta, chuta, aishte, among others.<sup>[8][9]</sup> *J. curcas* also contains compounds such as trypsin inhibitors, phytate, saponins and a type of lectin<sup>[10][11]</sup> known as curcin.<sup>[12]</sup>

The seeds contain 27–40% oil<sup>[13]</sup> (average: 34.4%<sup>[14]</sup>) that can be processed to produce a high-quality biodiesel fuel, usable in a standard diesel engine.<sup>[15]</sup> The oil has a very purgative property.<sup>[16]</sup> Edible (non-toxic) varieties, as those developed by selection by ethnic Mexican natives in Veracruz, can be used for animal feed and food.<sup>[17][8]</sup>

- Leaves: The leaves have significant variability in their morphology. In general, the leaves are green to pale green, alternate to subopposite, and three- to five-lobed with a spiral phyllotaxis.<sup>[18]</sup>
- Flowers: male and female flowers are produced on the same inflorescence, averaging 20 male flowers to each female flower,<sup>[19]</sup> or 10 male flowers to each female flower.<sup>[20]</sup> The inflorescence can be formed in the leaf axil. Plants occasionally present hermaphroditic flowers.<sup>[18]</sup>
- Fruits : fruits are produced in winter, or there may be several crops during the year if soil moisture is good and temperatures are sufficiently high. Most fruit production is concentrated from midsummer to late fall with variations in production peaks where some plants have two or three harvests and some produce continuously through the season.<sup>[18]</sup>
- Seeds: the seeds are mature when the capsule changes from green to yellow. The seeds contain around 20% saturated fatty acids and 80% unsaturated fatty acids, and they yield 25–40% oil by weight. In addition, the seeds contain other chemical compounds, such as saccharose, raffinose, stachyose, glucose, fructose, galactose, and protein. The oil is largely made up of oleic and linoleic acids. Furthermore, the plant also contains curcacin, arachidic, myristic, palmitic, and stearic acids and curcin.<sup>[18]</sup>

- Genome: the whole genome was sequenced by Kazusa DNA Research Institute, Chiba Japan in October 2010.<sup>[21]</sup>

*Jatropha curcas* can easily be propagated by both seed or cuttings.<sup>[22]</sup> Some people recommend propagation by seed for establishment of long-lived plantations.<sup>[23]</sup> When *jatropha* plants develop from cuttings, they produce many branches but yield fewer seeds and do not have enough time to develop their taproot, which makes them sensitive to wind erosion.<sup>[24]</sup> The seeds exhibit orthodox storage behaviour and under normal treatment and storage will maintain viability at high percentages for eight months to a year.<sup>[25][26][27][23][28]</sup> Propagation through seed (sexual propagation) leads to a lot of genetic variability in terms of growth, biomass, seed yield and oil content. Clonal techniques can help in overcoming these problems. Vegetative propagation has been achieved by stem cuttings, grafting, budding as well as by air layering techniques. Cuttings should be taken preferably from juvenile plants and treated with 200 micro gram per litre of IBA (rooting hormone) to ensure the highest level of rooting in stem cuttings.<sup>[29]</sup> Cuttings strike root easily stuck in the ground without use of hormones.<sup>[22]</sup>

Cultivation is uncomplicated. *Jatropha curcas* grows in tropical and subtropical regions.<sup>[30]</sup> The plant can grow in wastelands and grows on almost any terrain, even on gravelly, sandy and saline soils. It can thrive in poor and stony soils, although new research suggests that the plant's ability to adapt to these poor soils is not as extensive as had been previously stated. Complete germination is achieved within 9 days. Adding manure during the germination has negative effects during that phase, but is favorable if applied after germination is achieved. It can be propagated by cuttings, which yields faster results than multiplication by seeds.

The flowers only develop terminally (at the end of a stem), so a good ramification (plants presenting many branches) produces the greatest amount of fruits. The plants are self-compatible.<sup>[19]</sup> Another productivity factor is the ratio between female and male flowers within an inflorescence, more female flowers mean more fruits.<sup>[20]</sup> *Jatropha curcas* thrives on a mere 250 mm (10 in) of rain a year, and only during its first two years does it

need to be watered in the closing days of the dry season. Ploughing and planting are not needed regularly, as this shrub has a life expectancy of approximately forty years. The use of pesticides is not necessary, due to the pesticidal and fungicidal properties of the plant. It is used in rural Bengal for dhobi itch (a common fungal infection of the skin).

While *Jatropha curcas* starts yielding from 9–12 months time, the best yields are obtained only after 2–3 years time. The seed production is around 3.5 tons per hectare (seed production ranges from about 0.4 t/ha in the first year to over 5 t/ha after 3 years). If planted in hedges, the reported productivity of *Jatropha* is from 0.8 to 1.0 kg of seed per meter of live fence.

### 3. RESULTS

When *jatropha* seeds are crushed, the resulting *jatropha* oil can be processed to produce a high-quality biofuel or biodiesel that can be used in a standard diesel car or further processed into jet fuel, while the residue (press cake) can also be used as biomass feedstock to power electricity plants, or used as fertilizer (it contains nitrogen, phosphorus and potassium). The cake can also be used as feed in digesters and gasifiers to produce biogas.<sup>[32]</sup> There are several forms of biofuel, often manufactured using sedimentation, centrifugation, and filtration. The fats and oils are turned into esters while separating the glycerin. At the end of the process, the glycerin settles and the biofuel floats. The process through which the glycerin is separated from the biodiesel is known as transesterification. Glycerin is another by-product from *Jatropha* oil processing that can add value to the crop. Transesterification is a simple chemical reaction that neutralizes the free fatty acids present in any fatty substances in *Jatropha*. A chemical exchange takes place between the alkoxy groups of an ester compound by an alcohol. Usually, methanol and ethanol are used for the purpose. The reaction occurs by the presence of a catalyst, usually sodium hydroxide (NaOH) or caustic soda and potassium hydroxide (KOH), which forms fatty esters (e.g., methyl or ethyl esters), commonly known as biodiesel. It takes approximately 10% of methyl alcohol by weight of the fatty substance to start the transesterification process.<sup>[18]</sup>

Estimates of *Jatropha* seed yield vary widely, due to a lack of research data, the genetic diversity of the crop, the range of environments in which it is grown, and *Jatropha*'s perennial life cycle. Seed yields under cultivation can range from 1,500 to 2,000 kilograms per hectare, corresponding to extractable oil yields of 540 to 680 litres per hectare (58 to 73 gallons per acre).<sup>[33]</sup> In 2009 Time magazine cited the potential for as much as 1,600 gallons of diesel fuel per acre per year.<sup>[34]</sup> The plant may yield more than four times as much fuel per hectare as soybean, and more than ten times that of maize (corn), but at the same time it requires five times as much water per unit of energy produced as does corn (see below). A hectare of *jatropha* has been claimed to produce 1,892 litres of fuel.<sup>[35]</sup> However, as it has not yet been domesticated or improved by plant breeders, yields are variable.<sup>[36]</sup>

*Jatropha* can also be intercropped with other cash crops such as coffee, sugar, fruits and vegetables.<sup>[37]</sup>

In 2007 Goldman Sachs cited *Jatropha curcas* as one of the best candidates for future biodiesel production.<sup>[38]</sup> However, despite its abundance and use as an oil and reclamation plant, none of the *Jatropha* species has been properly domesticated and, as a result, its productivity is variable, and the long-term impact of its large-scale use on soil quality and the environment is unknown.<sup>[39]</sup>

In 2008 researchers at Daimler Chrysler Research explored the use of *jatropha* oil for automotive use, concluding that although *jatropha* oil as fuel "has not yet reached optimal quality, ... it already fulfills the EU norm for biodiesel quality". Archer Daniels Midland Company, Bayer CropScience and Daimler AG have a joint project to develop *jatropha* as a biofuel.<sup>[40]</sup> Three Mercedes cars powered by *Jatropha* diesel have already put some 30,000 kilometres behind them. The project is supported by DaimlerChrysler and by the German Association for Investment and Development (Deutschen Investitions- und Entwicklungsgesellschaft, DEG).

Aviation fuels may be more widely replaced by biofuels such as *jatropha* oil than fuels for other forms of transportation. There are fewer planes than cars or trucks and far fewer jet fueling stations to convert than gas stations.<sup>[41]</sup> To fulfil the yearly demand for aviation

fuel, based on demand in 2008 (fuel use has since grown), an area of farmland twice the size of France would need to be planted with *jatropha*, based on average yields of mature plantations on reasonably good, irrigated land.<sup>[42]</sup>

On December 30, 2008, Air New Zealand flew the first successful test flight from Auckland with a Boeing 747 running one of its four Rolls-Royce engines on a 50:50 blend of *jatropha* oil and jet A-1 fuel.<sup>[41][43]</sup> In the same press release, Air New Zealand announced plans to use the new fuel for 10% of its needs by 2013. At the time of this test, *jatropha* oil was much cheaper than crude oil, costing an estimated \$43 a barrel or about one-third of the June 4, 2008 closing price of \$122.30 for a barrel of crude oil.<sup>[44]</sup>

On January 7, 2009 Continental Airlines successfully completed a test flight from Houston, Texas using a 50/50 mixture of algae/*jatropha*-oil-derived biofuel and Jet A in one of the two CFM56 engines of a Boeing 737-800 Next Generation jet. The two-hour test flight could mark another promising step for the airline industry to find cheaper and more environmentally friendly alternatives to fossil fuel.

On April 1, 2011 Interjet completed the first Mexican aviation biofuels test flight on an Airbus A320. The fuel was a 70:30 traditional jet fuel biojet blend produced from *Jatropha* oil provided by three Mexican producers, Global Energías Renovables (a wholly owned subsidiary of U.S.-based Global Clean Energy Holdings), Bencafser S.A. and Energy JH S.A. Honeywell's UOP processed the oil into Bio-SPK (Synthetic Paraffinic Kerosene).<sup>[45]</sup> Global Energías Renovables operates the largest *Jatropha* farm in the Americas.<sup>[45]</sup>

On October 28, 2011 Air China completed the first successful demonstration flight by a Chinese airline that used *jatropha*-based biofuel. The mixture was a 50:50 mix of conventional jet fuel blended with *jatropha* oil from China National Petroleum Corp. The 747-400 powered one of its four engines on the fuel mixture during the 1-hour flight around Beijing airport.<sup>[46]</sup>

On August 27, 2018 SpiceJet completed the first successful test flight by an Indian airline which used *jatropha* based biofuel. The ratio of conventional jet fuel to *jatropha* oil was 25:75.<sup>[47]</sup>

#### 4. IMPLICATIONS

According to a 2013 study published by the European Geosciences Union,<sup>[48]</sup> the *jatropha* tree may have applications in the absorption of carbon dioxide, whose sequestration is important in combating climate change.<sup>[49]</sup> This small tree is very resistant to aridity so it can be planted in hot and dry land in soil unsuitable for food production. The plant does need water to grow though, so coastal areas where desalinated seawater can be made available are ideal. Currently the oil from *Jatropha curcas* seeds is used for making biodiesel fuel in Philippines, Pakistan and in Brazil, where it grows naturally and in plantations in the southeast, north, and northeast of Brazil. In the Gran Chaco of Paraguay, where a native variety (*Jatropha matacensis*) also grows, studies have shown the suitability of *Jatropha* cultivation<sup>[50][51]</sup> and agro producers are starting to consider planting in the region.<sup>[52]</sup> In Africa, cultivation of *jatropha* is being promoted and it is grown successfully in countries such as Mali.<sup>[53]</sup> *Jatropha* oil is being promoted as an easily grown biofuel crop in hundreds of projects throughout India.<sup>[54]</sup> Large plantings and nurseries have been undertaken in India by many research institutions, and by women's self-help groups who use a system of microcredit to ease poverty among semiliterate Indian women. The railway line between Mumbai and Delhi is planted with *jatropha* and the train itself runs on 15–20% biodiesel.<sup>[36]</sup> Myanmar is also actively pursuing the use of *jatropha* oil. On 15 December 2005, then-head of state, Senior General Than Shwe, said "the States and Divisions concerned are to put 50,000 acres (200 km<sup>2</sup>) under the physic nut plants [*Jatropha*] each within three years totalling 700,000 acres (2,800 km<sup>2</sup>) during the period". On the occasion of Burma's Peasant Day 2006, Than Shwe described in his a message that "For energy sector which is an essential role in transforming industrial agriculture system, the Government is encouraging for cultivation of physic nut plants nationwide and the technical know how that can refine physic nuts to biodiesel has also identified." He would like to urge peasants to cultivate physic nut plants on a commercial scale with major aims for emergence of industrial agriculture system, for fulfilling rural electricity supply and energy needs, for supporting rural

areas development and import substitute economy. (2005 from MRTV)

In 2006, the chief research officer at state-run Myanmar Oil and Gas Enterprise said Burma hoped to completely replace the country's oil imports of 40,000 barrels a day with home-brewed, *jatropha*-derived biofuel. Other government officials declared Burma would soon start exporting *jatropha* oil. Despite the military's efforts, the *jatropha* campaign apparently has largely flopped in its goal of making Burma self-sufficient in fuel. (2006 from MyawaddyTV)

Z.G.S. Bioenergy has started *Jatropha* Plantation Projects in Northern Shan State, the company has begun planting *Jatropha* plants during late June 2007 and will start producing seeds by 2010. (20 July 2007 from New Light of Myanmar) As of 2011 scepticism about the "miracle" properties of *Jatropha* has been voiced. For example: "The idea that *jatropha* can be grown on marginal land is a red herring", according to Harry Stourton, former business development director of UK-based Sun Biofuels, which attempted to cultivate *Jatropha* in Mozambique and Tanzania. "It does grow on marginal land, but if you use marginal land you'll get marginal yields," he said.<sup>[55][56]</sup> Sun Biofuels, after failing to adequately compensate local farmers for the land acquired for their plantation in Tanzania, pay workers severance, or deliver promised supplies to local villagers, went bankrupt later in 2011, the villager farmland being sold to an offshore investment fund.<sup>[57]</sup>

An August 2010 article warned about the actual utility and potential dangers of reliance on *Jatropha* in Kenya. Major concerns included its invasiveness, which could disrupt local biodiversity, as well as damage to water catchment areas.<sup>[58]</sup>

*Jatropha curcas* is lauded as being sustainable, and that its production would not compete with food production, but the *jatropha* plant needs water like every other crop to grow. This could create competition for water between the *jatropha* and other edible food crops. In fact, *jatropha* requires five times more water per unit of energy than sugarcane and corn.<sup>[59][60]</sup>

#### 5. CONCLUSIONS


Xuta, chuta, aishte or piñón manso (among others) are some of the names given in Mexico to edible

non-toxic *Jatropha curcas*.<sup>[61][9]</sup> It is grown in house gardens or other small areas.<sup>[61]</sup> Although it is known as a toxic plant due to the presence of diterpenes named phorbol esters,<sup>[62]</sup> the existence of edible non-toxic *J. curcas* without phorbol esters content has been demonstrated.<sup>[9][63]</sup> It is also similarly reported that *Jatropha* seeds are edible once the embryo has been removed.<sup>[64]</sup> The process for analysis of phorbol ester contents in *J. curcas* is done through high-performance liquid chromatography (HPLC).<sup>[65]</sup>

Xuta is traditionally prepared for local celebrations or popular parties. The kernels are roasted and eaten as a snack or roasted and ground to prepare different dishes, such as tamales, soups and sauces like "pipian".<sup>[9][63]</sup> The seeds in the zone around Misantla, Veracruz are very appreciated by the population as food once they have been boiled and roasted.

Root ashes are used as a salt substitute. HCN and rotenone are present.<sup>[66]</sup>

#### Flowers

 The species is listed as a honey plant. Hydrogen cyanide is present.<sup>[67]</sup>

#### Nuts

Can be construed for home cooking fuel in briquette form replacing charcoalized timber as in Haiti.<sup>[68]</sup>

They can be burned like candlenuts when strung on grass. HCN is present.

Used as a contraceptive in South Sudan.<sup>[70]</sup>

#### Seeds

Interest exists in producing animal feed from the bio-waste once the oil is expressed, as in the case with Haiti, where *Jatropha curcas* grows prolifically and animal feed is in very short supply.<sup>[68]</sup>

Similarly, Metsiyen in the Haitian culture dates back as a medicinal crop—thus the name "metsiyen"/"medsiyen". Some suggest it "calms the stomach".<sup>[68]</sup>

Also used as a contraceptive in South Sudan.<sup>[70]</sup>

The oil has been used for illumination, soap, candles,

the adulteration of olive oil, and making Turkey red oil. Turkey red oil, also called sulphonated (or sulfated) castor oil, is the only oil that completely disperses in water. It is made by adding sulfuric acid to pure *Jatropha* oil.<sup>[71]</sup> It was the first synthetic detergent after ordinary soap, as this allows easy use for making bath oil products. It is used in formulating lubricants, softeners, and dyeing assistants.<sup>[72]</sup>

#### Bark

Used as a fish poison. HCN is present.<sup>[73]</sup> Igbinosa and colleagues (2009) demonstrated potential broad spectrum antimicrobial activity of *J. curcas* bark extract.<sup>[74]</sup>

#### Latex

Strongly inhibits the watermelon mosaic virus.<sup>[75]</sup>

#### Leaves

Leaf sap can be used to blow bubbles.<sup>[76]</sup>

#### Sap

It stains linen. Sometimes used for marking.<sup>[77]</sup>

#### Shrub

Used for erosion control.<sup>[78][79]</sup>

#### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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