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# Jatropha Oil: A Sustainable Biofuel

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**Abstract**
This article looks at the future scope of Jatropha Oil as a sustainable Biofuel. Depletion of fossil fuels and spiking environmental pollution has drawn focus to healthy alternatives to conventional fuels, petrol and diesel. Jatropha Oil has been propagated as one such alternative in the past decade. But, like any other energy resource, it has advantages as well as disadvantages. There are multiple debates going on about the pros and cons of using Jatropha oil. But there is a necessity of being able to solve the limitations and considering the possible upcoming energy scenario. This implies the future possibility of an era where there is no energy security. The depleting fossil fuels and high pollution demand for this revolution. This paper provides some inputs for the future scope of Jatropha Oil as a sustainable biofuel, used to combat pollution problems and solve fuel crisis.

**Keywords:** Jatropha oil, Sustainable biofuel, Gas chromatography.

## Introduction

Fossil fuels play an important role in the development of every economy. In India, more than half of the energy demand is met by conventional fuels including coal, petroleum, diesel etc. But the use of conventional fuels had its toll on nature and in turn on life itself. Since then, the quest for efficient nature-friendly energy sources began. Alternative fuels have gained importance due to their environmentally friendly nature. The last decade has witnessed a major shift from conventional fuels to environment-friendly biofuels. Jatropha Oil is one such good biofuel [2,4].

Jatropha Curcas is an angiosperm genus of about 175 shrubs or small trees. They are perennials whose individual fruit contains 2-3 seeds. Jatropha is generally found in tropical to sub-tropical regions of the world. Due to its high resistance and low water requirement for plant growth, Jatropha can easily be cultivated in areas of high aridity or even on wastelands. For the very same purpose, many wastelands were converted into Jatropha plantations. Biofuel missions and policies were launched by the Indian Government for the sake of this revolution. Extracted from Jatropha seeds, Jatropha oil is one such good source of energy [4,7].

## Jatropha Biofuel

Biofuels has been propagated as a renewable energy source with great potential in the past decade. As a renewable energy resource, Jatropha is being mainly used in the manufacture of biodiesel. It yields oil-rich seeds. The seeds are cracked and carefully deshelled. The kernels are processed to obtain Crude Jatropha Oil. Then begins the production of Biodiesel. The oil can directly be used for combustion. Trans esterified Jatropha Oil can be used in a standard diesel engine. Government of India has accepted Jatropha Oil as an alternative to conventional diesel. Biodiesel is also produced from vegetable oils, yellow grease, used cooking oils, or animal fats. Apart from Jatropha Seeds, the raw materials for biodiesel productions also consist of agricultural forest and residue (materials not including food), and Lignin-cellulosic raw materials. [1,5] Jatropha oil contains around 39 compounds. The major constituents are the δ-cadinene (9.6%), α-epi-cadinol (7.38%), pulegone (5.95%), chrysanthenyl acetate (5.26%), α-cadinol (4.32%), thymol (4.03%) [10].

**Production of Biofuel**

Biodiesel production involves two major steps. The first step is to reduce the fatty acids in the jatropha oil with sulphuric acid and methanol. The second step is the process of transesterification where the product formed is separated into biodiesel and glycerin.

**Step 1:** Acid Catalyzed Esterification

Acid catalyzed esterification is the process where the free fatty acid contents of jatropha oil is removed. It was established that complete free fatty acid esterification from Jatropha Curcas oil using stirred method, could be done in the optimum conditions where even concentrations as small as 1% are also removed. Then the sample of oil is analyzed using titration method and by means of infrared attenuated total reflection and gas chromatography. The optimal parameters are used for the next process. [11,12]

**Step 2:** Alkali Base Catalyzed Transesterification

In the alkali base catalyzed transesterification process, the optimal reaction is carried out with various methanol. The reaction mixture consists of esterified jatropha oil with methanol and alkaline catalyst (sodium hydroxide). The alkali base catalyzed transesterification ultrasonic process is carried out. The optimal reaction parameters are maintained throughout the process. The mixture is allowed to settle at least overnight before separating the glycerol layer to get the methyl ester layer of fatty acids on the top. Then the product is analyzed using gas chromatography for ester content and glycerol content. The purification is then carried out under the optimal reaction parameters. [11,12]

**Scenario of Jatropha Biofuel**

As of March 2022, the use of Jatropha for biodiesel production has been a failure due to low yield, globally. 0.5-1.5mg/ha. Per year was the obtained yield while the expected was 2-5 mg/ha. Per year. The expected and farmers' profits were much lower. The situation was even worsened due to the unavailability of oilseeds. Jatropha also increases weeding changing local habitats and leading to the loss of biodiversity.

**Merits**

**The Following are the Merits of Jatropha Which gives it Significance as a BIO-fuel**

1. **High Yield:** Jatropha Curcas is a cheap biodiesel feedstock with good calorific value and more oil than its other sister species. The crop has a high yield, and the calorific value of biodiesel is higher (39-41 MJ/kg) compared with other liquid fuels. The extraction of oil is also maximum. Jatropha has a higher saturated fat content compared to other edible raw materials of Biodiesel production.
2. **Ease of Cultivation and Harvesting:** Jatropha can be grown in a variety of soils, highly fertile to infertile. The water requirement is also low. Jatropha is easy to grow and maintain. It does not require irrigation or any other kind of maintenance. It is drought resistant and not grazed by cattle. The plant once mature can be harvested for over 50 years. The size of the plant makes the process of harvesting much easier. Currently, many countries grow Jatropha locally, in order to manufacture biodiesel, for fulfilling their energy demands. India is one such country currently observed to be expanding their Jatropha cultivation.
3. **Food Security:** 95% of biodiesel is produced from edible oil crops, which jeopardizes the food security of the economy. As a result, exploring cheap and non-edible oil-bearing energy crops is a necessity. That's where Jatropha comes into the play. Being a non-edible oilseed feedstock, it will have no impact on food prices or the food vs fuel debate.
4. **Bio Sequestration:** Cultivation of Jatropha is also considered as a form of Bio sequestration, where CO2 in the atmosphere is converted into biomass through the process of photosynthesis. Bio-sequestration is important because this will help also in the revival of the non-renewable energy resources.
5. **Cost-effective:** The seeds of Jatropha are cheap. The labor charge involved in the irrigation, maintenance and harvesting of the produce is comparatively lower. Thus, Jatropha cultivation could be highly profitable when produced in masses. [4,8,9]

**Demerits**

Biodiesel is considered as renewable energy that can substitute petrol diesel consumption with numerous advantages. However, sustainable biodiesel production from this plant is not achieved yet due to various ecological, socioeconomic, legislative, and technological factors.

1. **Scarcity of Agricultural Land:** One of the main problems in agriculture is usually land- related. Loss of viable land is a major issue. Therefore, finding land for mass cultivation of Jatropha is a challenge for Jatropha oil production.
2. **Variation in the Yield:** Even when they are told to be highly resistant, Jatropha may be host to a few diseases and is affected by pests. Jatropha is sensitive to frost and water logging. However, all factors are strongly correlated, and the impact of one factor is significantly affected by the situation of other factors. Therefore, the present review is devoted to critically examining and discussing the sole and interactive effect of various factors affecting the cultivation of Jatropha for sustainable biodiesel production by reviewing more than 185 published articles. The variety used also affects the yield. All the above factors contribute to the variation of yield. The yield is variable every time.
3. **Need for Timely Irrigation and Fertilization:** Even though adaptable in nature, Jatropha doesn't flourish unless provided with enough water and necessary nutrients. This means irrigation and fertilization charges are also involved. In the absence of which low seed production or poor seed quality is observed, which will in turn result in low oil-yield.
4. **Long Maturation Phase:** As a renewable energy source, Jatropha is mainly used in the manufacture of biodiesel. Extensive cultivation of Jatropha was encouraged due to its advantages like adaptability and ease of cultivation. But even these advantages came about with a stretch. The gestation period of Jatropha plants goes from 3 to 5 years.
5. **Long Term Impact on the Environment:** Jatropha is observed to have an invasive nature when they start to grow in any area. It may sometimes cause weed problems. The long-term impact of using Jatropha for oil extraction on the environment is still unknown.
6. **Production of Value-added Products:** Toxicity in Jatropha species is a major drawback. Due to the presence of several toxic compounds, Jatropha and its parts are generally inedible. A few edible, non-toxic Varieties are used for animal or fish feed. But still, pollination of non-toxic varieties with the toxic ones could lead to a risk of ingestion of the toxins. Ingestion of

the toxic varieties leads to vomiting, diarrhea, abdominal pain and burning sensation in the throat. Any applications of Jatropha cannot be successful until it is detoxified and wherever necessary the toxicity of the product derived should be studied. Thus, the application is narrowed down in pharmaceutical industry.

7. **Characteristics of Jatropha Oil:** The fact that Jatropha oil has a shelf life, out of which it deteriorates, was also a drawback. The viscosity of Jatropha oil limits its uses during the cool climates.
8. **Processing of Jatropha Oil:** Various oil extraction and biodiesel production technologies and factors affecting the physicochemical properties of Jatropha oil and biodiesel were profoundly investigated. The production of Jatropha-based biofuel is not considered viable, on a financial level. The process proved to be time and energy consuming. The esterification process done to refine the oil requires alcohol which increases the cost of biodiesel production.

   Due to the above disadvantages, the outcome won't be as successful as expected. The long- term impact of using Jatropha for oil extraction is still unknown. Above all, the knowledge gap and research gap in this field has led to many failures. [1,3,8,9]

## Conclusions

The performance, combustion, and emission characteristic of diesel engines fueled with Jatropha biodiesel were carefully reviewed and compared with petrol diesel. Due to the multiple advantages of Jatropha oil, it can be considered as a potential sustainable biofuel. Research continues in search of more viable and creative applications this biofuel may have. The challenges of using Jatropha oil still stand due to the properties like toxicity, sensitivity, water requirements etc. The uncertainties about the uses, the processing and safety of using Jatropha are yet to be overcome. But if the knowledge gap and research gap in this field is overcome, Jatropha oil has the potential to replace many conventional diesel and petrol, at least partially. Hence, it is concluded that Jatropha should be considered an important research topic, which could make breakthroughs in the Renewable Energy Sector.

In conclusion, factors affecting the sustainable biodiesel production potential of Jatropha vary across growing regions due to variation in determinants, and the performance and emission characteristic of diesel engines fueled with Jatropha biodiesel slightly differed from petrol diesel.

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