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Production of Biodiesel from Jatropha Curcas: A Review

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Abstract:- Biodiesel has received a lot of attention and is gaining popularity as a green alternative to fossil diesel all over the world as fossil diesel have a negative impact on the environment, producing global warming, air pollution, and fossil fuel depletion. One of the most promising alternatives to conventional fossil fuels is the use of liquid fuels such as biodiesel made from Jatropha oil through a transesterification process. Because biodiesel has low emission profiles and environmentally favourable characteristics, as well as being non-toxic and non-flammable, it can readily be used as a substitute for fossil diesel. The generation of biodiesel from jatropha oil is the subject of this study. Biodiesel can be made from both edible and non-edible vegetable oils, as well as animal fat. The extraction of oil, pretreatment, transesterification, and separation processes in the manufacturing process of biodiesel from jatropha seeds are all described in this paper. The qualities of jatropha oil, such as flash point, specific gravity, and boiling point, and the parameters related to the jatropha plant, such as genetics, growth factors, plant nutrition, site parameters, botanical features, flowering and fruiting habits, and ecological requirements, are all studied. Transesterification is the process of reacting alcohol and oil to give biodiesel and glycerol. This process is also affected by some of the parameters, like reaction time, the molar ratio of alcohol and oil, reaction temperature, and moisture content.

Keywords:- *Transesterification, Biodiesel, Bioling point.*

I. INTRODUCTION

Biodiesel is an environmentally friendly diesel fuel that has consumption properties similar to top petro-diesel.Biodiesel is a methyl or ethyl ester of fatty acid made from renewable biological resources such as vegetable oils (edible and non-edible). Jatropa Curcus has been recognised as a new energy source with many promising benefits. Plants of the Jatropa genus originated in Mexico and were spread to Asia and Africa by Portuguese traders.When grown under ideal conditions, Jatropa Curcua produces more oil per hectare than peanuts, sunflowers, soya, and maize. It belongs to the family of "Euphorbiaceoae". Jatropa oil-producing seeds have been found to be toxic to humans and most animals, earning them the moniker of "purge nut." The extraction of biocrude oil from Jatropa seeds is expected to generate huge quantities of seedcake. It occurs mainly at lower altitudes (0-500m) in areas with average annual temperatures above 20 degrees Celsius. The oil content of Jatropha is around 40%, and it does not require refining. The beauty of Jatropa is that it can grow on dry land (non-agricultural) and that it is a carbon-neutral fuel. This is a liquid fuel made by chemically processing vegetable oil and modifying its characteristics to mimic petroleum diesel. Although biodiesel and petroleum diesel are quite similar, they are not the same. When comparing the procedures for manufacturing biodiesel and petro diesel, however, the difference is extremely minor.

Transesterification is a chemical process that involves utilising methanol to change the chemical characteristics of a vegetable oil to produce biodiesel. Vegetable oil transesterification is a reasonably simple process that produces a high conversion rate with glycerin as by product.

For transportation and agricultural machinery, all countries are currently heavily reliant on petroleum fuels.The fact that only a few countries generate the majority of petroleum has resulted in high price volatility and supply uncertainty for the world's consumers. The need to research and develop alternative energy sources is increasing in modern times, owing to a reduction in the attraction of traditional energy sources such as fossil fuels, which have been present for a long time. Fossil fuels have been related to a number of environmental and ecological issues that have arisen as a result of its extraction, production, and ultimately intended usage. Normal gasoline and diesel automobiles produce "greenhouse gases," such as CO2, which trap heat from the sun in the upper atmosphere, resulting in greenhouse gas emissions, climate change, and polar areas. It also releases pollutants into the atmosphere, including as hydrocarbons and nitrogen oxides, which have been linked to health problems like respiratory sickness and cancer. This prompted a search for alternatives to conventional fuels. That is good for the environment. As a result, they're looking for alternate fuels that they can make themselves. Methanol, ethanol, biogas, and vegetable oils are among the options being studied.

A. Genetics

Jatropha originated in Central America, and the seeds are widely exported to Europe for use in soap production.Up to 45000 tons of jatropha seeds were exported to Japan in the 1920s and 1930s.They then spread to many African countries, where they were used as folk remedies until the 1980s.

While forecast yields of up to 12 ton of seed per ha were being made in the development of many commercial plantings, in most schemes it was rare that yields approaching 1 tonne per ha were achieved, and not uncommon that seed averages per 5 year-old plant of under 0.2 kg were recorded (though oddly, there are many references in the literature of yields from mature hedges of around 0.8 kg per meter, which may suggest that very close planting of jatropha can result in a significant benefit for yield).

China, Vietnam, Indonesia, the United States, Australia, Germany, the Netherlands, and Belgium are among the nations where improved Jatropha strains have been developed or are being developed. All of this work focuses on the same set of features. These include increased yield, higher oil percentages, oil and seedcake non-toxicity, and productivity with lower rainfall. All of this work focuses on the same set of features. These include increased yield, higher oil percentages, oil and seedcake non-toxicity, and productivity with lower rainfall.

B. Factors effecting

Many factors influence the yield of jatropha, including soil type, climatic conditions, rainfall, and the average summer temperature. The genetic quality of Jatropha is an important factor in the average yield, and site selection is another important factor in Jatropha yield.

The climate at the site plays an important role in site selection (rainfall, summer average extreme temperatures and winter average extreme temperatures, evaporation rate).Effective shelter belt design can manage some variables, such as wind speed, which disrupts the plantation. Irrigation systems that have been in place for a long time can help to alleviate the effects of heavy rain.

C. Handling and storage

Once the fruits of the plants have been plucked, they must be handled with care, dehusked, dried, and then stored. If this step is skipped, the free fatty acids in the seeds, which are already at high levels, will rise to great depths. The cost of manufacturing biodiesel from seeds rises correspondingly as a result of this.If the usual alkaline-catalyst transesterification reaction is used as FFA levels grow above 1%, soapy residues and foaming will emerge in increasing degrees. To overcome this, a preceding stage of acid-catalyst processing (esterification) may be introduced, resulting in a decline in biodiesel output per litre of jatropha oil from the low 90s to the low 80s.The fruit should be spread out to dry in a dimly lit, airy area, according to numerous publications. With far bigger amounts to deal with, drying and dehusking will have to be mechanized.Most oil seed crops are quickly pressed, and the moisture content of the fresh oil is removed afterwards. This is the method for pressing palm oil, as well as a variety of other vegetable oils. Although some seeds, such as canola/rapeseed and cotton seeds, may have very low moisture content, it is unlikely in a big commercial processing system that the seed is entirely dried before pressing .However, it is recommended that the moisture level of jatropha be between 2 and 6% for best result when pressing.

D. Properties

The high viscosity of jatropha curcus oil, which has been investigated as a possible alternative fuel for compression ignition (C.I) engines, can be lowered by combining it with diesel. Biodiesel production relies heavily on the quantity and consistency of oil. Density, flash point, cold solidfying point, centane number, and sulphur percent are some of the most important attributes to have in an oil.Jatropha oil has a low free fatty acid content, which increases its stability and allows it to remain fluid at low temperatures due to the presence of unsaturated fatty acids.Jatropha oil has a low free fatty acid content, which increases its stability and allows it to remain fluid at low temperatures due to the presence of unsaturated fatty acids.

The low sulphur percentage indicates that the oil emits less harmful SO2 exhaust emissions when used as fuel, and it has other properties such as a low acid value, among others. low content of phosphorus.

The specifications of Jatropha oil are listed in the table below. [11]

Property	Value
Boiling point	124 °C
pH	5.2
Free fatty acids	0.0718 mg KOH g^{-1} oil
Specific gravity	0.8480
Flash point	150 °C
Cloud point	14 °C
Saponification value	155 mg KOH g^{-1} oil
Peroxide value	7.20 meq g^{-1} oil
Iodine value	51.27 g 100 g^{-1} oil
Dielectric strength	22 kV
Pour point	4 °C
Density at 27 °C	0.725 g cm^{-1}

Fig. 1: Properties of jatropha oil

E. Botanical features

It's a little tree or shrub with a smooth grey back that emits a runny milky latex when cut. It normally grows to a height of three to five metres, but under the right conditions, it can reach a height of ten metres.It has big green to pale green leaves, alternating to sub-opposite leaves that are three to five lobed and have a spiral phyllotaxis.

F. Fruits

The length of the petiole varies from 6 to 23 mm. In the leaf axil, the inflorescence develops. Female flowers are slightly larger and appear during the hot seasons, and blooms are formed terminally, individually. An imbalance of pistillate or staminate flower production results in a larger number of female flowers under settings where continuous growth occurs.

G. Seeds

After two to four months, the seeds mature when the capsule changes from green to yellow.[9]

H. Flowering habits

The trees are deciduous, meaning they lose their leaves in the winter. Flowering occurs during the wet season, and there are usually two flowering peaks. In humid climates, flowering takes place all year. After three months of blossoming, the seeds mature.Early development is rapid, and nursery plants can give fruit after the first rainy season if rainfall circumstances are favourable. Insects, particularly honey bees, fertilise the flowers.

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I. Ecological Requirements

Jatropha has the advantage of growing practically everywhere, including sandy, saline, and rocky soils. The organic content in dropped leaves helps to boost the soil's fertility. They are usually found in the tropics and subtropics, and they favour heat above cold. Jatropha is also good for avoiding soil erosion and dunes scouring.

J. Plant nutrition

It is supposed to have had lower fertiliser requirements because it was grown in poor soils. Plant yields can, however, be increased with greater nutrition.On wasteland in India, Ghosh et al. (2007) found that 3.0 tonnes per ha of jatropha seed cake (also known as “press” cake), containing 3.2 percent N, 1.2 percent P2O5and 1.4 percent K2O, increased yields significantly when applied to young plants – by +120 percent and +93 percent at two different planting densities.[10]

The application rate of nutrients required to maintain soil fertility levels is determined by analysing the nutrient value of harvested fruit, assuming all other biomass is retained in the field.

From the nutrient composition calculated by Jongschaap et al. (2007), the fruit equivalent of 1.0 tonne of dry seed per ha removes 14.3–34.3 kg of N, 0.7–7.0 kg of P, and 14.3–31.6 kg of K per ha.[10]

TABLE 2: **EFFECT OF FERTILIZER LEVELS ON YIELD PARAMETERS OF JATROPHA CURCAS AT ICRISAT, THREE YEARS AFTER PLANTING (INDIA)**

	TREATMENTS (GRAMS PER PLANT)				
	T1	T2	T3	T4	T5
Pods/plant	97.1	90.1	131.4	45.9	53.6
Pod weight (g)	350.9	248.7	390.8	130.7	148.9
Seeds/plant	247	210	341	131	133
Seed weight/plant (g)	168	143	233	83	87
Threshing%	48	57.4	59.5	63.4	58.3
100 seed weight (g)	68	67.8	68	63.1	65.2

Fig. 2: Effect of fertilizers on yeild of jatropha

K. Advantages

There are many plants suitable for the production of biodiesel. So the question is, why to you choose Jatropha?

There are numerous advantages to growing, processing, and using jatropha.The amount of energy available in the fuel is represented by the caloric value.The lower the particular fuel usage, the higher the calorific value.According to research, the calorific value of jatropha is between 38 and 42.5 MJ/kg.When compared to petro-diesel, it has a high oxygen concentration, which aids in complete burning and boosts biodiesel combustion efficiency.The ability of a fuel to ignite and burn is determined by its flash point.Because of its high viscosity, jatropha oil has a high flash point.

The following are some of the advantages of Jatropha:

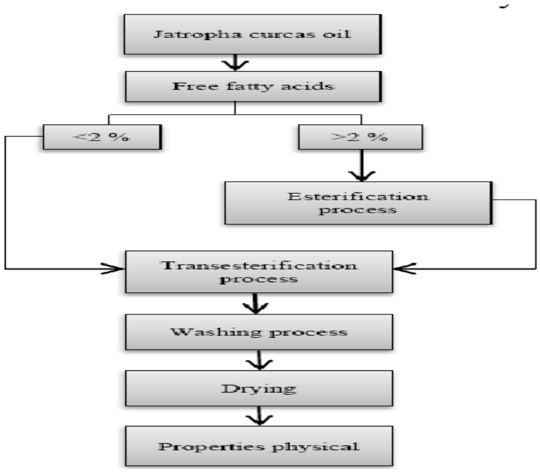
- Oil extraction is a highly efficient process.
- The cultivation procedure is simple.
- These are adaptable to a wide range of climates and soil conditions.
- The rate of product yield is quite high.
- Seeds are inexpensive.
- The time of development is extremely brief.
- The amount of water needed for maintenance and cultivation is quite low.
- Jatropha plants can also be used to make soaps and fertilisers.

II. PROCESS

The transesterification process can be used to make biodiesel.Transesterification reduces the viscosity of the oil, increasing engine efficiency and allowing for more uniform combustion of the fuel.One hectare of typical soil yields 400 to 600 litres of oil.Several factors influence the oil content, including growth conditions and the soil on which it is grown.The first and most important step in producing biodiesel from jatropha seeds is the extraction of oil from the seeds.The extraction of oil from jatropha seeds can be done in five different ways.

- mechanical extraction
- Aqueousous extraction
- Extraction method based on three phases.
- The SCE method
- GAME method

As a result, the three phase partitioning method " is a very effective method."It is capable of extracting 97% of the oil from jatropha seeds.



[15]

Fig. 3: Production process of biodiesel from jatropa oil

A. Pretreatment

By turning FFA into esters, the esterification reaction is utilised to decrease FFA.The FFA level of jatropha oil is typically 14-19.5 percent.As a result, the esterification procedure is used to reduce the FFA content to less than 2%.The yield of biodiesel is increased as a result of this method.

This procedure begins with the introduction of jatropha oil into the reactor (mixing chamber), followed by the addition of determined amounts of acid catalyst, 4 percent H2SO4, and methanol (30 percent v/v) to the chamber. The mixture is then boiled for 1 hour at 60 degrees Celsius. The impeller speed is 600rpm and the working pressure is atmospheric pressure.

The mixture is then allowed to settle for 30 minutes, after which the low-density layers of methanol-water fraction are removed. For the transesterification procedure, the bottom setteled is trigylcerides with a <2 percent FFA content and an acid value of 0.3 mg KOH/g is uesd.

B. Transesterification

Transesterification is the reaction of fatty acid alkyl esters, methyl and ethyl esters, and glycerol with alcohol to produce fatty acid alkyl esters, methyl and ethyl esters, and glycerol.In this reaction, one mole of oil combines with three moles of alcohol to yield three moles of alkyl esters (biodiesel) and one mole of glycerol (co-product).

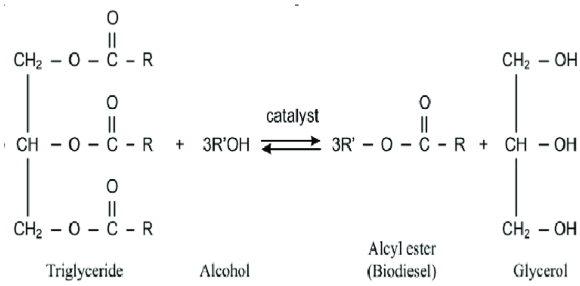


Fig. 4: Transesterification reaction

Excess alcohol is utilised to move the equilibrium to the product side because this is a reversible reaction.As a result of the process, the viscosity of the vegetable oil changes drastically.Because glycerol, a high viscous component, is removed, the result has a low viscosity.To enhance the effectiveness of the transesterification process, an excess of alcohol is required.Methanol, ethanol, propanal, and butanol are some of the alcohols that can be used.

The use of methanol is more viable due to its inexpensive cost, physical and chemical advantages, and the fact that it has the shortest alcohol chains.There are two types of transesterification: a) with a catalyst and b) without a catalyst.

Catalysts are classified as alkalis, acid enzymes (or) heterogneous.Alkali catalysts, such as sodium hydroxide (NaOH) and sodium methoxide, are more effective in this case.Sodium methoxide is shown to be more effective than NaOH.However, NaOH is employed because of its inexpensive cost.

Methanol is employed as the alcohol in this tranesterification reaction, and NaOH is employed as the catalyst.Transesterification is a reaction in which a mixture of an ester and alcohol produces methyl alcohol.

In a round bottom flask, 1g of NaOH is mixed with 1000ml of 99.5 percent pure methanol and vigorously agitated, then heated to 70 degrees Celsius to evaporate moisture.The 200ml of jatropha oil has been heated up.The methanol and NaOH combination is transferred into a flask containing 200ml of warmed jatropha oil, which is then heated for 1 hour at 60 degrees Celsius with stirring at 700rpm.The methanol-to-oil ratio is kept at 5:1.

This mixture is poured into a separate funnel and allowed to settle for one day under gravity.There were two layers developed. The top layer is biodiesel (methyl ester), and the bottom layer is glycerine.Jatropha methyl ester (biodiesel) is washed with hot distilled water to remove the unreacted alcohol and remains a catalyst and a soap.Characterization is done on the separated biodiesel.

Several aspects influence the process, including moisture effect, reaction time, and reaction temperature.

C. Effect of moisture

Because water causes the transesterification reaction to partially convert to saponification reaction, which produces soap, the yield of esters is reduced.Because it increases viscosity and causes gel formation.Because they include a significant proportion of FFA and water, a huge variety of low-cost oils and fats cannot be converted to biodiesel using methanol and an alkaline catalyst.

D. Effect of reaction time

With increasing reaction time, the rate of conversion increases.As a result, in the transesterification reaction, reaction time is a significant aspect.

E. Effect of reaction temperature

Depending on the oil used, the transesterification process can occur at various temperatures. The reaction is usually carried out at the boiling point of methanol (60-70 degrees Celsius), at atmospheric pressure, and with a molar ratio of 6:1. (alcohol to oil).

F. Effect of molar ratio

To produce 3 moles of fatty esters and 1 mole of gylcerol, the transesterification process takes 3 moles of alcohol for 1 mole of trigycleride.To get a higher yield of methyl esters, a molar ratio of 6:1 (alcohol to oil) is utilised (biodiesel).The yield does not increase when the ratio is larger than 6:1.

III. CONCLUSION

Despite having the same issues as other similar bioenergetic raw materials, the energy usage of Jatropha curcas has proven to be competitive when compared to other biofuels.Jatropha cultivation can be done with low returns on barren soils. The growth of the jatropha plant is influenced by factors such as soil nutrition, handling, storage, climate, and water supply. Out all the different alcohols available, methanol or ethanol is most commonly used for transesterification reactions. Acid catalyst is superior for processing vegetable oil with higher levels of free fatty acids for biodiesel generation. Moisture, molar ratio, reaction temperature, and reaction time all play a role in the maximal generation of biodiesel.

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