BIOFUEL: A CLEANER AND GREENER ALTERNATIVE TO FOSSIL FUELS.

Abstract

Biofuel is considered as pure and the easiest available fuels on planet earth. This book chapter examines the feasibility of biofuels as a solution to the world's energy crisis. Plant biomass can be used for multiple forms of bioenergy and there is a very large potential supply. This fuel produced directly or indirectly from organic material including plant materials and animal waste. Biofuels are drawing increasing attention worldwide as substitutes for petroleum-derived transportation fuels to help address energy cost, energy security and global warming concerns associated with liquid fossil fuels. Ethanol and biodiesel are produced through different biochemical/chemical pathways, fermentation and transesterification are the major pathways for ethanol and biodiesel production. Demand for various oils and their high prices is an apprehension for the mankind. Since there is an increased awareness for eco-friendly issue, there is an urgent need to explore the alternative energy sources. Various alternative energy sources like nuclear power, solar, wind and biofuels are well known, where biofuels (solid, liquid, gas fuels) sounds as one of the best representative candidates in terms of usage and the production process. Biofuel, is the process where energy of organic materials (renewable biomass) is replaced the function of fossil fuels.Some biofuel crops include corn, sugarcane, palm oil, cottonseed, sunflowers, wheat and soybean, Jatropha Rapeseed and Canola, Mustard, Camelina. It helps in maintaining a cleaner environment, there is no emission of hazardous gases, such as Carbon monoxide (CO) and sulphur oxide (SO).Using biofuels rather than fossil fuels, there is the only emission of non-toxic materials, which

Authors

Ms. Priyanka Rathore
Assistant Professor
Institute of Pharmacy
SAGE University
Indore, Madhya Pradesh
India.

Dr. Kratika Daniel
Professor
Faculty of Pharmacy
Oriental University
Indore, Madhya Pradesh
India.

Dr. Vivek Daniel
Principal & Professor
NTVS Institute of Pharmacy
Nandurbar, Maharastra
India.

Dr. Anil K Gupta
Professor
Jaipur College of Pharmacy
Jaipur, Rajasthan
India.

reduces the risk of cancer and breathing problems in human beings. Biofuels are friendly to the environment because they reduce the risk of global warming. The *jatropha* – a genus of flowering plants in the spurge family. This is a source of biofuel and is widely cultivated in many regions of the world. In this chapter we discussed about various crops utilized in the production of biofuels.

Keywords: Biofuel, biomass, bioenergy, Herbal biofuel, Jatropha

I. INTRODUCTION

A fuel (gas, liquid, or solid) made from biomass is known as a biofuel. Biofuels are generally defined as gaseous and liquid fuels made from biomass, which might include plant, algal, or animal waste. (National Policy on Biofuels, 2018, https://nitsri.ac.in/Department/Chemical%20Engineering/BRTL12.pdf retrieved on 1st August 2023)

Other renewable sources of energy can be used to create a variety of energy-related products, such as electricity, liquid, solid, and gaseous fuels, heat, chemicals, and other materials. Biomass is produced by burning biological materials to produce heat. Biofuels and biogas are produced by processing biological materials to create fuels like biodiesel and bioethanol. Dedicated energy plants and trees, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, animal wastes, municipal wastes, and other waste materials are all included in the definition of biomass. [Demirbas 2007]

II. CLASSIFICATION OF BIOFUELS

Broadly classified as:

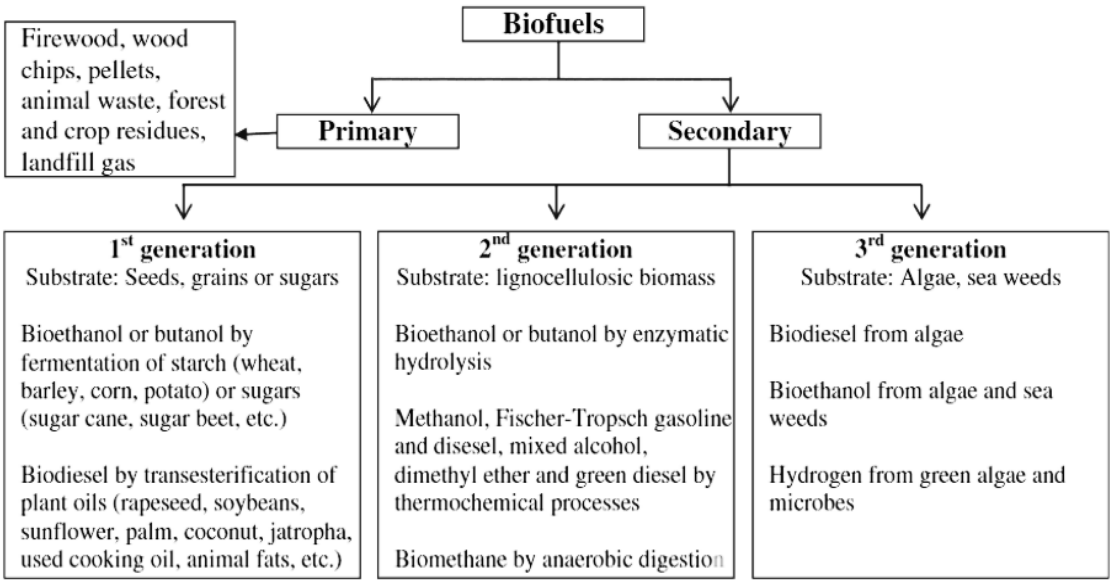

Figure 1: Classification of Biofuel

2018, https://nitsri.ac.in/Department/Chemical%20Engineering/BRTL12.pdfretrived on 1st August 2023)

1. **First-Generation Biofuels:** (from seeds, grains or sugars) These are produced using traditional technologies from food sources including sugar, starch, vegetable oil, or animal fats. Bioalcohols, Biodiesel, Vegetable Oil, Bioethers, and Biogas are examples of typical first-generation biofuels.

- Petroleum-gasoline substitutes – Ethanol or butanol by fermentation of starches (corn, wheat, potato) or sugars (sugar beets, sugar cane)
- Petroleum diesel substitutes – Biodiesel by transesterification of plant oils, also called fatty acid methyl ester (FAME) and fatty acid ethyl ester (FAEE) From rapeseed (RME), soybeans (SME), sunflowers, coconut, palm, jatropha, recycled cooking oil and animal fats – Pure plant oils (straight vegetable oil)

2. **Second-Generation Biofuels:** (From lignocellulosic biomass, such as crop residues, woody crops or energy grasses)These are made from non-food crops or by-products of food crops that are considered wastes since they cannot be eaten, such as fruit peels, husks, stems, and wood chips. Such fuels are created through thermochemical reactions or biochemical conversion processes. Examples include biodiesel and cellulose ethanol.

- Biochemically produced petroleum-gasoline substitutes – Ethanol or butanol by enzymatic hydrolysis
- Thermochemically produced petroleumgasoline substitutes – Methanol – Fischer-Tropsch gasoline – Mixed alcohols. **(unctad.org)**

3. **Third Generation Biofuels:** These are created by microbes like algae. Consider butanol. Algae can be cultivated on land and in water that are not suited for food production, which relieves pressure on already-depleted water supplies.

4. **Fourth Generation Biofuels:**Crops that have been genetically modified to absorb large amounts of carbon are cultivated and harvested as biomass in the creation of these fuels. Then, utilising second-generation processes, the crops are transformed into fuel. Pre-combustion of the fuel occurs, and carbon is captured. The carbon is then geosequestered, which refers to the storage of the carbon in exhausted oil and gas fields or unmineable coal seams.[https://www.drishtiias.com/printpdf/biofuels-1retrived on 11th July 2023]

III. THERE ARE SEVERAL REASONS FOR THE EXCITEMENT SURROUNDING BIOFUELS

1. **Biofuels can Reduce Carbon Emissions:** Biofuels can lower carbon emissions, and they are occasionally viewed as a climate change solution. The direct carbon emissions from the combustion of biofuels are negligible when compared to those from fossil fuels, notwithstanding the fact that this may be overly optimistic.

2. **Biofuels are Replenishable**: Since agriculture can replenish the stock, biofuels are an endless resource. Fuel cell and electric car technologies, for example, are reliant on the electric grid and hydrogen, respectively, and thus on finite resources like natural gas and coal.

3. **Biofuels can Increase Farm Income**: Today, the global reduction in farm revenue is a problem [Gardner, 2003]. With the development of biofuels, the majority of nations will be able to cultivate one or more crop kinds in which they have a competitive advantage and use them to satisfy either domestic or international demand, or both.

4. **Biofuels have Physical and Chemical Properties Similar to Oil:** In comparison to alternatives, biofuels more closely resemble petrol or diesel in terms of their viscosity, specific energy density, liquid state, and combustion properties. With simple changes, they may be burned in existing internal combustion engines. As a result, switching to biofuel-based infrastructure can be done more affordably than switching to hydrogen, batteries, or natural gas-powered cars (at least at low levels of blending like 10% or 20%).[Ugarte 2006; Fulton, Howes, Hardy 2004].

5. **Biofuels can Create New Jobs:** In terms of labour costs per supplied unit of energy, biofuels are more labor-intensive than other energy methods.[Kammen, Kapadia, and Fripp 2004]. Compared to the mining and processing of fossil fuels or other industrially based technologies like hydrogen and electric vehicles, the manufacturing of the feedstock and the conversion demand more labour. The majority of these job increases are anticipated to occur in rural areas, which can help promote rural development. [Kammen 2006, Deepak Rajagopal 2007]

6. **Biofuels are simple and familiar:** originally came from the sun and was stored in the cells of the plants as a result of photosynthesis, which the plants used as a feedstock for the manufacture of biofuel. For the production of biofuels, numerous plants and components produced from plants are used.

IV. ADVANTAGES OF BIODIESEL

- Offers a domestic source of renewable energy.
- Since the amount of CO2 emitted and the amount of CO2 absorbed by the plants that produce vegetable oil are equal, biodiesel is carbon neutral.
- Compression ignition engines can use biodiesel without the need for significant engine modifications.
- Biodiesel and diesel fuel can be blended to improve engine performance.
- Because biodiesel has a higher flash point, storage is safer.
- Biodiesel has no harmful effects.
- Diesel deteriorates four times more slowly than biodiesel.
- CO, CO2 and UBHC, PAH, soot and aromatics emissions are reduced in biodiesel and its blends than in fossil diesel because biodiesel is oxygen in structure and it burns clearly all the fuels.
- It degrades naturally.

V. PLANT BIOMASS CAN BE USED FOR MULTIPLE FORMS OF BIOENERGY, AND THERE IS A VERY LARGE POTENTIAL SUPPLY

Corn, sugarcane, palm oil, cottonseed, sunflowers, wheat, soybean, Jatropha rapeseed, canola, mustard and camelina are some examples of biofuel crops. As there are no emissions of dangerous gases like carbon monoxide and sulphuroxide, [Kerckhoffs, 2013] the atmosphere is kept cleaner. The only emission of non-toxic compounds occurs when using biofuels in place of fossil fuels, which lowers the risk of cancer and breathing issues in people. The fact that *J. curcas* cannot be utilized as food without first being detoxified makes it particularly appealing as an energy source for making fuel. [Parawira,2010]

1. **Jatropha:** Biodiesel is a type of alternative fuel typically made from plants. It is environmentally responsible and renewable as a result. Because Jatropha can be grown in a variety of climates, the potential for replacing fossil diesel with biodiesel seems bright. [GAPKI,2017.Maftuchaha [*J. curcas* L. is a member of the Euphorbiaceae family, which is well known for possessing species that are in violation of the Geneva Conventions on Chemical Warfare. The Greek words jatros (doctor) and trophe (food), which denote usage in medicine, are the source of the genus name Jatropha. [Sarin,2007, Parawira,2010]

   Jatropha curcas seeds can be processed to create a high-quality biodiesel fuel that can be used in a conventional diesel engine because they contain between 27 and 40 percent oil**.** [Achten, 2008]This is especially true if the oil from the seeds is effectively extracted.

   Jatropha oil may be transformed into a useful bio-diesel that can be utilised in standard diesel engines using a procedure called transesterification. [Achten, W,2008, Adams, D] Due to the significant search for alternative fuel, biodiesel manufacturing is one of the current research topics in academia. Based on this, scientists have published numerous studies looking at the manufacture of biodiesel using acid and base catalyzed transesterification from various seed oils and kernels. By using a sodium hydroxide catalyst and methanol, [Okullo, 2015]one study examined the impact of temperature and mixing rate modification on the generation of biodiesel from Jatropha. In the study, it was discovered that high temperatures and vigorous mixing increased the rate constants of the process. It was also discovered that the reactions were driven by a second order rate equation.

   Three main phases are involved in the general production of biodiesel from *Jatropha curcas* oil: drying the seeds, extracting the oil, and transesterification (the conversion of pure vegetable oil into biodiesel).

   Biodiesel processing of *Jatropha curcas* [Koh, 2011, Nurul, 2020]
   - Jatropha plant cultivation
   - Fruit harvesting
   - Pretreatment
   - Seeds/kernels storage
   - Oil extraction
   - Crude oil purification
   - Transesterification
   - Water - Biodiesel Purification- Washed Water
   - Biodiesel Storage

   Density, viscosity, flash point, cloud point, and pour point of the produced biodiesel were found to be extremely similar to those of diesel. [Jamil, 2012] The best yield of the methyl ester could be obtained with the oil to methanol molar ratio of 1:16 and KOH catalyst concentration of 1.5%, according to another study on the kinetics of biodiesel production from Jatropha curcas seed oil by varying molar ratio of oil to methanol, reaction temperature, and catalyst.

Biodiesel Manufacturing By reacting the extracted Jatropha oil with methanol in the presence of potassium hydroxide (which has been reported to give high yield and conversion of the transesterification reaction with minimal side reaction) as a catalyst, ester and glycerol were produced during the transesterification process, which is the process of turning extracted oil into biodiesel. Glycerol and biodiesel separated into two layers at the conclusion of the reaction. Glycerol was at the bottom of the old container after it had settled, while biodiesel was at the top. Later, the layers were separated from one another by draining the glycerol from the mixture's flask's bottom. [Fahad, 2016]

Biodiesel production: The base catalysed transesterification method is chosen in this study to convert Jatropha oil into biodiesel. A batch reactor is used to carry out the transesterification-ion process. 500 cc of Jatropha oil are heated to 700 C in a round bottom flask to drive off moisture and are then aggressively agitated during the transesterification process. It uses 99.5% pure, 0.79 g/cm3 density methanol. In a separate container, 2.5 g of catalyst NaOH was dissolved in bimolar amounts of methanol. The liquid was then placed into a round bottom flask while being continuously stirred. For 60 minutes, the combination was kept at 60°C and atmospheric pressure. After the transesterification process is finished, the mixture is allowed to settle naturally in a separating funnel for 24 hours. Jatropha oil methyl ester and glycerin were the byproducts of transesterification. Glycerin, excessive alcohol, catalyst, contaminants, and residues of unreacted oil make up the bottom layer. Alcohol, soap, and biodiesel make up the top layer. Simple distillation produces 80–88% pure glycerin that can be sold as crude glycerin from the evaporation of water and alcohol. Jatropha methyl ester (biodiesel) is combined, washed with hot distilled water to get rid of the alcohol that hasn't been reacted with it, added to oil, and then given 25 hours to settle naturally. A sample of the separated biodiesel is obtained for analysis. [S.Antony Raja,2011]

2. **Canola, Rapeseed, and Mustard:** Rapeseed is one of the most significant oils used for the production of biodiesel even though mustard seed oil is not currently a typical biodiesel feedstock. Rapeseed has the potential to be a less expensive feedstock than the two most typical oilseeds used for biodiesel (canola and soybeans). Rapeseed is one of the most popular oils used in Europe to make biodiesel. Brassica napus is another name for rapeseed. being a member of the Brassicaceae family

   Field mustard (Brassica campestris L. or Brassica Rapa var.) or rapeseed (Brassica napus L.) are two cultivars that go by the name "canola." Its seeds are used to make edible oil that may be consumed by both people and animals. The oil can also be used to make biodiesel.

   Biodiesel, which is used to fuel automobiles, is made from rapeseed oil. Modern engines can run on biodiesel in its pure form without suffering any damage, and it is routinely mixed with regular fuel in amounts ranging from 2% to 20% biodiesel. Rapeseed-derived biodiesel used to be more expensive to create than regular diesel fuel because of the costs associated with cultivating, crushing, and refining the fuel. Most of Europe uses rapeseed oil as its main oil source for biodiesel manufacturing, in part because it yields more oil per unit of land area than alternative oil sources like soy beans. **(Biodiesel)**

The oil content, fatty acid composition, and physicochemical characteristics of white mustard oil extracted using different methods from seeds and press cake.

A promising oily feedstock for biodiesel manufacturing is white mustard seed oil. [Ciubota-Rosie et al., 2013]. It is regarded as unfit for human eating in many nations. White mustard seed can be used as a spice, however due to its potent flavor and high erucic acid content, its broad use in the food industry is constrained. [Wendlinger et al., 2014] As a result, its use as a substitute feedstock for the production of biodiesel will not conflict with that of its usage as food for people. is immune to a variety of illnesses. Erucic acid is transesterified to create alkyl esters, which have excellent lubricating characteristics for improved engine performance [Issariyakul et al., 2011]. Additionally, white mustard can emerge naturally on cultivated or abandoned land, usually in rotation with cereal crops [Falasca and Ulberich, 2011; Rahman et al., 2018, Petar M]. Additionally, it can thrive on various types of soil and is disease-resistant.

Harvesting of the seeds, pre-cleaning, drying, storing, and pretreatment, as well as oil recovery, refinement, and packing, make up the whole process of producing white mustard oil. 2020 [Petar M., 2020]

Biodiesel is a term for mono-alkyl esters of long-chain fatty acids generated from vegetable oils or animal fats. Because it is non-toxic, biodegradable, and benzene-free, biodiesel can significantly lower the dangers to public health brought on by air and environmental pollution. This is one of its main benefits.

Transesterification: Transesterification of triglycerides with methanol in the presence of basic catalysts to produce fatty acid methyl esters (FAME) is the method that produces biodiesel most frequently. which, compared to the original vegetable oil, are substantially less viscous. A by-product of transesterification is glycerol, which gravitationally tends to separate from the ester phase. The alcohols ethanol, isopropyl alcohol, and butanol are additional potential substitutes for methanol. As transesterification catalysts, amines, amidines, guanidines, and triamino(imino)phosphoranes have been investigated as well as acid and alkaline metal hydroxides, alkoxides, carbonates, enzymes, and non-ionic bases.

3. **Camelina:** The broadleaf oilseed flowering plant known as camelina, or Camelina sativa (L.) Crantz, thrives best in temperate areas and is also known as false flax or gold-of-pleasure. Important food crops like broccoli, Brussels sprouts, cabbage, cauliflower, collards, kales, kohlrabi, radish, rapeseed/canola, rutabaga, turnips and various mustards are also more prevalent members of this family. Camelina can be grown as a spring or summer annual crop, a biannual winter crop, or in a range of climatic and soil circumstances.

   Production of Biofuel: The traditional method of making biodiesel involves trans esterifying lipids in the presence of excess methanol and a homogeneous alkali catalyst at a high (608C) temperature. Low free fatty acid content crude feedstocks (less than 3.0 wt%) can be immediately trans esterified without pretreatment, obviating the need for an expensive pretreatment step. One such crude oil is camelina, which has been successfully transformed into biodiesel (fatty acid methyl esters) using both the conventional method and heterogeneous metal oxide catalysts, both with and without microwave irradiation, as well as at non-catalytic sub- and supercritical conditions using co-solvents with methanol [Moser, 2010]. Camelina-based biodiesel is suitable for use as biodiesel since its fuel characteristics—such as cold flow qualities, oxidative stability, kinematic viscosity, cetane number, etc.—are comparable to those of biodiesel made from soybean oil. Additionally, methyl esters and fatty acid ethyl esters from camelina oil were assessed as mix components in petrodiesel (a15 ppm S). Camelina-based biodiesel blends in petrodiesel displayed fuel qualities similar to the corresponding soybean-based blends, as was the case with the plain esters.

4. **Sunflower:** In lab tests, the generation of biodiesel from sunflower oil and ethanol using sodium hydroxide as a catalyst has been examined. The goal is to investigate how the amount of catalyst and the ratio of ethanol to oil affect the yield and quality of the biodiesel that is produced.

It can be extracted from sunflower seeds (Helianthus annus) mechanically or chemically. Different sunflower types have been created using biotechnological techniques. High quantities of linoleic acid can be found in the original oil. A significant portion of the crude oil is wax. The oil needs to have the waxes taken out of it. The refined oil is yellow in colour and has a crystalline look.

Due to concerns over environmental protection, socioeconomic factors, and energy security, alternative fuels are now absolutely necessary (Hossain, 2009). Biodiesel has become more popular as an alternative fuel for diesel engines during the past few years. It is relatively simple and has numerous positive environmental effects to produce biodiesel from recycled vegetable oil (M. Allen, 2002). Vegetable oils used for frying produce a lot of wasted oil, which could be difficult to dispose of.Their low cost makes them ideal for use in the manufacturing of biodiesel. Used vegetable oil is referred to as a "renewable fuel" because, unlike fossil fuels, it does not alter the atmosphere by emitting additional carbon dioxide gas (K. Kalisanni, 2008). Vegetable oil derived from plants is the greatest starting material for biodiesel production from a chemical reaction standpoint since it converts pure triglycerides to fatty acid methyl ester at a high rate and does so in a short amount of time (M. Allen, 2002) Sunflower seed oils, methanol, and NaOH were refluxed together in the traditional transesterification method in a 500 ml glass reactor fitted with a mechanical stirrer shaped like an anchor made of glass, a water condenser, and a funnel. The reaction was terminated once the vegetable oil had completely converted, and the mixture was left to stand for phase separation, with the ester mixture forming the upper layer and the glycerine-containing layer forming the bottom layer (Hossain, 2010). Between the two phases, the remaining catalyst and unreacted alcohol were dispersed. The ester mixture was phase separated using a separatory funnel, dried over anhydrous sodium sulphate, and then subjected to gas chromatography analysis.’

Production of biofuel: Sunflower oil, ethanol, and the catalyst (NaOH) are the primary ingredients in the reaction. A fume cupboard is used to create the reaction. The many steps for producing biodiesel in a laboratory are as follows:

- In a flask, combine the catalyst and ethanol. As little moisture as possible should be present. By means of saponification, soap is created. It's important to stop soap from forming. The separation and purification process is complicated by soap formation, which uses up the catalyst. The output of biodiesel is also decreased by soap formation.

- To dissolve the catalyst entirely in the ethanol, the mixture of ethanol and NaOH is heated to 50°C (in a water bath) and agitated by a magnet at 800 rpm (constant speed).
- Heat 200 cc of sunflower oil to 60 °C.
- In a flask, the oil and the ethanol catalyst solution are combined. A water bath set at 50°C with the flask added and being swirled at 500 rpm. The reaction takes place for 60 minutes.
- A separating funnel is filled with the finished solution. The biodiesel is in the top layer, and the byproduct glycerol is in the bottom, darker layer.
- Take the glycerol out of the biodiesel and measure it.
- To remove the catalyst residue, 50 ml of 5 weight percent phosphoric acid are added to the biodiesel. (The process for making 5 weight percent H3PO4 is given in appendix 2).
- Calculating the volume of biodiesel produced.
- Analysis of the density, viscosity, and refractive index of the biodiesel produced.
- The catalyst weight and ethanol/oil ratio are changed as the experiment is repeated several times. (Alejandro,2011)

5. **Soybean:** Because of worries about the environment, global warming, and the depletion of the world's petroleum supplies, alternate energy alternatives to petroleum-based fuels are required. According to Singh and Singh (2010), biodiesel is the best fuel to replace diesel because it is clean and renewable. One of the main feedstocks used to produce biodiesel is soybean oil. Soybeans can be used to make ethanol in addition to biodiesel. Producers choose to use soybean hulls for animal feeding due to their high protein content and considerable amount of carbohydrates for ethanol production (Mielenz et al., 2009). Although biodiesel is typically used in various blends with petro-diesel, compression ignition engines can run entirely on the fuel. According to the findings of engine emission testing, using biodiesel alone resulted in lower CO, HC, NOx, and smoke emissions than using petro-diesel (Qi et al., 2009). The oil extraction and biodiesel conversion steps are carried out separately in conventional biodiesel manufacturing from soybeans. Mechanical presses, solvent extraction, supercritical fluid extraction, and solvent extractions aided by microwave and ultrasound are all methods used to extract oil from soybeans.

The soy bean (Glycine max) is used to make soybean oil. Soybean production is extremely high worldwide. Both mechanical and solvent extraction techniques are used to get soybean oil. Between 2.5 and 3.0% of the crude oil is made up of phospholipids. The oil must go through a refining procedure and chemical degumming to remove the phospholipids. Unsaturated fatty acids, particularly linoleic and linolenic acid, are present in the oil. The crude oil has been bleached, deodorised, and refined in preparation for bottling.

The grains must be pretreated in order to extract the oil from soybeans. Cleaning, drying, dehulling, and grinding are all included in pretreatment. The main methods used to extract oil from soybeans include the use of mechanical presses, solvent extraction, supercritical fluid extraction, and oil extraction assisted by microwave and ultrasound.

- **Mechanical Extraction:** Automated Extraction One of the most popular ways to extract oil around the world is through mechanical pressing of the oil seeds. However, according to Singh and Bargale (2000), single screw mechanical presses leave 8–14% of the accessible oil in the oil seeds. Heat is used in mechanical extraction to counteract the effects of enzymes. Using an extruder is a productive approach to supply heat for enzyme neutralisation. Extruders apply sufficient pressure and heat to seeds to render enzymes inactive (Gerpen et al., 2002). For the extraction of oil and protein, Jung and Mahfuz (2009) employed a dry extruder with a high temperature. They discovered that higher extruder pressure increased the solubility of proteins in soybean oil..

- **Solvent Extraction:** Hexane's low vaporization temperature, excellent stability, low corrosiveness, and minimal greasy residual effects make it widely employed for oil extraction from soybeans and other oilseeds [Seth et al., 2007]. Johnson and Lucas (1983) suggested switching out hexane for alternative non-petroleum solvents. They listed a number of issues with hexane, including its price dependence on the market for fossil fuels and its detrimental consequences on the environment [Gandhi et al., 2003]. According to Russin et al. (2010), soybean oil can be extracted using more than 70 different solvents. The use of different alcohols in oil extraction, however, was the main focus of many recent studies (Russin et al., 2010). According to Seth et al. (2007), using isopropyl alcohol led to higher oil recovery and extraction rates than using hexane. When Chilean chickpea oils were extracted using hexane, isopropanol, and a 3:2 mixture of the two, Lou et al. (2010) compared the results. The extraction rates were higher when hexane and isopropanol were combined than when they were used separately.

- **Supercritical Fluid Extraction:** In a relatively recent method [Mendes et al., 2002], supercritical carbon dioxide was used to extract the oil and isoflavones from soybeans. Supercritical carbon dioxide (SC-CO2) was utilised by [Zaidul et al., 2007] to extract oil from palm kernels. Salgin (2007) extracted oil from jojoba oilseeds using a blend of supercritical CO2 and supercritical ethanol. Their findings indicated an increase in the speed of oil extraction. The key factors affecting supercritical fluid extraction were temperature and pressure [Salgin, 2007]. Supercritical carbon dioxide extraction produced better oil yields than solvent extraction, according to Kao et al. (2008) who compared the two methods [Kao et al., 2008].

- **Microwave-assisted Extraction:** Chilean hazelnut oil extraction and oil quality were studied by Uquiche et al. in 2008. In the pretreatment stage, they employed the microwave approach, which was followed by mechanical pressing. According to their findings [Uquiche et al., 2008], microwave application enhanced the oil's quality and quantity. [Kashyap et al., 2009] suggested enzymatic hydrolysis as a different technique to improve oil extraction from soybeans. Enzymatic hydrolysis had a noticeable impact on the oil extraction from soybean flakes when this approach was used after pretreatment, according to the results [Kashyap et al., 2007[. Terigar et al. [2010] evaluated the extraction of isoflavones from soybeans using traditional solvent extraction vs microwave-assisted solvent extraction. In compared to solvent extraction, they claimed that the continuous microwave approach enhanced oil and isoflavone yields.

- **Refining Oil:** The first phase in the refinement of oil is called degumming, and it aims to remove the phospholipids from the oil by adding hydrating chemicals. The oil companies primarily used two degumming techniques: water and acid (Ribeiro et al., 2008). Membrane separation was employed by Pagliero et al. (2007) as an alternative method of oil degumming. In comparison to traditional degumming procedures, they proposed membrane separation as a viable technique.

- **Biodiesel Production**

  - **Transesterification Method:** In place of direct esterification, transesterification is frequently used to produce biodiesel from vegetable and animal fats (Abreu et al., 2003). Alky esters and glycerol are produced when fats or oils and alcohol interact during transesterification or alcoholysis (Meher et al., 2006). Oils that have a higher viscosity than petro-diesel are made less viscous using the transesterification process (Stavarache et al., 2005). Choosing the right alcohol and catalyst is crucial for the transesterification process. Transesterification can be done with a variety of alcohols, including methanol, butanol, ethanol, propanol, and amyl alcohol. Because it is physically and chemically superior to other alcohols and is comparably less expensive than other alcohols, methanol is utilised frequently (Ma & Hanna, 1999). According to theory, in order to make 3 moles of fatty acid methyl ester (FAME) and 1 mole of glycerin, 1 mole of triglyceride must be neutralised by 3 moles of alcohols (Leung et al., 2010). To transesterify triglycerides at a decent rate and convert them to biodiesel, a good catalyst is also required. For the transesterification process, homogeneous or heterogeneous acid and alkaline catalysts can be utilised (Pereira et al., 2007). Alkali catalysts, such NaOH and KOH, are used in research and industry because they react more quickly and are less corrosive than acidic chemicals. High levels of water and free fatty acids in oil make soap and lower the efficiency of catalysts while requiring a lot of catalysts. Before using the base catalysis procedure, it is necessary to separate the free fatty acids (FFAs) and water from the oil. By using an acid catalyst, Marchetti et al. (2008) were able to solve the aforementioned issues. They claimed that because acid catalysts are able to convert a higher percentage of free fatty acids (FFAs) to triglyceride, they perform better than base catalysts. Sulfuric acid is the top option for acid catalysts and has been employed by numerous researchers (Marchetti &Errazu, 2008). Enzyme catalysts are a potential alternative to acid and base catalysts for the generation of biodiesel. The enzyme catalysts have grown in popularity in recent years due to their straightforward method and lack of soap component. Currently, enzymatic catalysts are not practical for commercial manufacturing due to their greater cost and longer reaction times. (Leung et al., 2010).

  - **Ultrasound-Assisted Transesterification:** Several steps of the synthesis of biodiesel involved the use of ultrasound technology. Low frequency ultrasonic energy was employed by Stavarache et al. (2005) to produce biodiesel and compare the outcomes to those of traditional biodiesel production methods. They employed NaOH as a catalyst and three various Soybeans Processing for Biodiesel Production 23 types of alcohols. They demonstrated how ultrasonication improved the transesterification process, shortened the time required for the process, and conserved energy during the synthesis of biodiesel (Stavarache et al., 2005). Santos et al. (2009) investigated how ultrasonication affected the process of turning soybean oil into biodiesel. As a catalyst, they utilised KOH and methanol. They demonstrated how ultrasound can increase biodiesel yield (Santos et al., 2009). In order to produce biodiesel from soybeans, Cintas et al. (2010) used high power ultrasound in a continuous system. They heated the oil and mixed it with a mechanical stirrer before using ultrasound. Their findings demonstrated a sizable improvement in time and energy savings (Cintas et al., 2010). Using response surfaces approach, Koc and McKenzie (2010) investigated how ultrasonication affected the separation of glycerol during the transesterification of soybean oil. Additionally, Yu et al. (2010) noted that ultrasonication enhanced the generation of biodiesel. They converted soybean oil into biodiesel using ultrasonic waves (Yu et al., 2010). Li et al. (2004) investigated the impact of ultrasonic time on soybean oil extraction and contrasted the outcomes with the traditional extraction method. The outcomes revealed a significant improvement in the end product's quantity and quality. (A. Bulent, 2011)

6. **Palm Oil:** Since more than 5000 years ago, people have used palm oil, which is made from the fruit of the *Elaeisguineensis* palm tree. Western Guinea is the native home of this tree. Along the equator, it was spread starting in the fourteenth century to various regions of Africa, Southeast Asia, and Latin America.

   - **Transesterification:** Methanol and sodium hydroxide, together with energy to shake the oil and ingredients to create biodiesel, are needed for the transesterification of palm oil. The 20,000 liter batch-type reactor used in our calculations for making biodiesel from palm oil operates at a maximum of three batches per day with a reactor time of eight hours each (PLEANJAI et al. 2004). 50 to 60 °C is the working temperature. Around 16 t of biodiesel are produced every batch. The result of the oil's transesterification is a mixture of glycerol and methyl esters (biodiesel). Gravity is used to separate the biodiesel from the glycerol, and the residual mixture is then washed in acetic acid and water until the washing water is neutral. The methyl ester is subsequently heated to dry it. Approximately 87% of the processed crude palm oil is converted into biodiesel. A stoichiometric material balance can be used to determine the yield percentage for the manufacturing of biodiesel. A by-product, glycerol can be used to make soap or other products.We calculated the inputs of CPO, water, grid power, methanol, and sodium hydroxide, as well as the outputs of methyl ester and glycerol, for the transesterification stage.

   - **Biodiesel Technology**

     - **Palm Oil processing:** With an annual CPO production of 15 tonnes, Indonesia is currently the greatest palm oil producer in the world. About half of the overall production of CPO is consumed domestically, with the remaining production going to export. Finding other uses for CPO, such as palm oil biodiesel, is crucial given the recent price volatility of CPO and the anticipated rise in supply. By creating a blend of bio-petrodiesel, petroleum diesel should eventually be replaced with palm oil biodiesel.

- **Palm oil biodiesel technology:** Chemically speaking, biodiesel is a methyl ester made from natural oils like old frying oil, animal fats, or vegetable oils. Biodiesel can be used alone or in mixtures with diesel made from petroleum. It burns cleanly, is renewable, non-toxic, and biodegradable. A mono alkyl ester or methyl ester with a C chain ranging from 12 to 20 is what biodiesel is chemically. The difference between biodiesel and petroleum diesel is the length of the C chain. Due to the physical similarities between petrodiesel and biodiesel, they can be blended together or used in diesel engines separately. Even though it is comparable to petrodiesel, biodiesel is cleaner, safer, and easier to handle than petrodiesel because it has a higher flash point, which makes it less flammable, and because it doesn't include sulphur or benzene, both of which are carcinogens. In essence, palm oil and methanol are transesterified to create biodiesel. Such a technique is carried out in batches or continuously between 50 and 70 o C. Glycerin and biodiesel are the goods.(Soni,2011)

Advantages of Bio-Diesel

The benefits of biodiesels are numerous. Here are some of the most significant:

- Biodiesel can be used in any standard, unaltered diesel engine. Use of the engine doesn't require any modifications.
- Biodiesel, without "engine conversion." Alternatively said, "you just pour it into the fuel tank."
- Biodiesel can be kept anywhere regular diesel fuel is kept. Biodiesel may be used in all diesel fueling infrastructure, including pumps, tanks, and transport trucks, without requiring any significant adjustments.
- Carbon dioxide emissions, which are the main contributor to the greenhouse impact, are reduced by up to 100% by biodiesel. Utilising biodiesel does not result in a net increase in carbon dioxide because it is derived from plants, which breathe carbon dioxide.
- Biodiesel can be used alone or combined with petroleum diesel fuel in any ratio. The terms "B20" and "B5" for biodiesel and diesel fuel blends, respectively, of 20% and 5%, are now in use. Because it is non-toxic and biodegradable.
- biodiesel is safe to handle and provides more lubrication than diesel fuel. It also lengthens the life of engines and can be used to replace sulphur, a lubricant that when burned creates sulphur dioxide. The national bio-diesel board claims that "neat diesel is as biodegradable as sugar and less toxic than salt."
- It's safe to transport biodiesel. The flash point, or ignition temperature, of biodiesel is higher than that of petroleum diesel fuel, which is 52°C.
- Biodiesel-powered engines function normally and get comparable gas mileage to conventional diesel-powered ones. The effects of biodiesel on auto ignition, fuel usage, power output, and engine torque are minimal.

7. **Cotton Seed:** After the cotton lint has been removed, cottonseed oil is a vegetable oil that is produced from the seeds of the cotton plant. Palmitic acid (22–26%), oleic acid (15–20%), linoleic acid (49–58%), and a 10% mixture of arachidic acid, behenic acid, and lignoceric acid are all abundant in cottonseed oil. The amount of sterculic and malvalic

acids in the crude oil is also about 1%. Even though the cyclopropene acids are unwanted byproducts, refining largely eliminates them.

VI. BIODIESEL PRODUCTION METHODS

Transformation of vegetable oils into biodiesel can be realized using four technologies:

- Dilution/blending.
- Micro-emulsion.
- Heating/pyrolysis.
- Transesterification.

1. Production of Biofuel

- Transesterification of Crude Cottonseed Oil
- Transesterification Reaction of Oil

The best procedure for turning oils and fats into biodiesel is transesterification. It is the most often utilized reaction for reducing viscosity while converting vegetable oils into biodiesel. In the presence of sodium hydroxide, the crude cottonseed oil and methanol interacted to form methyl esters of fatty acids (biodiesel) and glycerol. An experimental strategy with three levels and five factors (25) was used to optimize the aforementioned transesterification process. A precise quantitative transfer of the crude cottonseed oil into an Erlenmeyer flask submerged in the Gyratory water bath shaker was made. Then a precise amount of sodium hydroxide was added, which had been dissolved in the necessary quantity of methanol (by weight of crude cottonseed oil). Throughout the reaction, the reaction flask was maintained in the water bath at a consistent temperature with a specific amount of agitation. The sample was removed at the predetermined time, cooled, and the biodiesel—represented by the methyl ester in the upper layer—was separated from the by-product—represented by the glycerol in the bottom layer—by settling overnight in an environment with no special conditions. By comparing the weight of the up-layer biodiesel with the weight of the additional crude cottonseed oil, the percentage of the biodiesel yield was calculated. [Xiaohu et.al, 2011]

With the aid of a magnetic stirrer with a heater and three necked flasks, the equipment for making biodiesel was used in the lab.

- For the synthesis of biodiesel, cotton seed oil, ethanol, and catalyst (sodium hydroxide) were utilized.
- A reflux condenser, magnetic stirrer, and a 500 ml batch reactor were included in the transesterification system. 500 cc of cotton seed oil were initially added to the reactor, which was then heated to the necessary temperature.
- The three necked round bottom flask was preheated at different temperatures of approximately (80*, 90*, 95* Celsius) and then the different mole ratios of ethanol to oil, *i.e.*, 3:1, 6:1, and 9:1, and known amounts of catalyst varied from (1, 2, 3 wt%), were added.
- To which the mechanical stirrer, condenser, and temperature gauge (thermometer) were then applied to fix.

- Following the completion of the reaction, a mixture was allowed to cool before the solid catalyst was filtered out to obtain the desired product.
- The methyl ester and glycerol phases of each sample were allowed to stabilise while the reactor's contents were refluxed for 90 minutes.
- The mixture is then kept in the separating funnel for 24 hours before being separated using it. [Patil & Patil, 2021]

2. **Purification of Crude Biodiesel:** On a small scale, dry washing is an intriguing technique because it uses no water. Water and other pollutants are removed from biodiesel using adsorbents like Magnesol (a commercial adsorbent made of amorphous magnesium silicate). The adsorbing capability of such adsorbents is one of their key drawbacks. To prevent saturating the adsorbents, the majority of the remaining alcohol must have been removed during earlier purification steps. [Student P.G, 2018]

VII. ENVIRONMENTAL AND OTHER FACTORS

In contrast to conventional diesels made from petroleum, biodiesel is a toxic-free energy source that is also sustainable and renewable. The usage of biodiesel, which is biodegradable as well, lowers the amount of carbon dioxide released into the atmosphere. In order to stop the ever-increasing flood of global warming, weather disturbances, and the consequences of El Nino and La Nina, the UN-sponsored Kyoto agreement has established the limit of carbon dioxide (CO_2) emission into the atmosphere [Howell, 1997]. All nations in the world signed the agreement with the exception of the USA, whose CO2 emissions per person are more than 20 times higher than those of the majority of poor nations [Fernando & Hanna, 2004].

Because photosynthesis, the process by which plants create their food for development, consumes atmospheric CO2 in the presence of solar energy (sunlight), biodiesel aids in reducing the amount of CO2 that builds up in the atmosphere. Even though CO2 would be released into the atmosphere when the fuels are consumed in vehicles or for other heating reasons, the net result is a reduction in atmospheric CO2 because some plant materials (roots, stems, etc.) are still left unused. The use of biodiesels does not, in contrast to petroleum products, release sulphur compounds into the atmosphere, which is another significant benefit. Sulphur compounds are dangerous to human health and can also cause "acid rain" in some parts of the planet.

The production, harvesting, and processing of these energy sources will result in the creation of jobs in Nigeria as biodiesel is developed.

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