# A SURVEY : BIODIESEL AN EFFICIENT SOURCE

**Mrs. Ankita K. Patil[a], Dr. Jayant H. Bhangale[b]**

**Abstract:** Energy utilization and energy saving is always focused topic for any nation. In this paper, first of all, energy scenario after and before covid-19 is studied. Energy scenario is explaining the vast scope of energy development in the field of bio-fuels, which is the main objective of my research project. Also, as per energy scenario, CO2 emissions produced counts India as a leading nation. This effect can be minimized with the help of biofuel/biodiesel preparation and use in vehicles. In this paper, classification of bio-fuels as first generation, a second generation and third generation is studied and reviewed. Main focus of this paper is on the generation of fuel from non-edible seeds of plants and its availability for the feedstock needed in blend preparation. Bio-diesel produced from edible-oil/non-edible oil/animal waste/plant waste also studied. List of feedstock or raw material available for bio-diesel is reviewed. Meaning of blend, blend preparation methods, engine setup requirements, engine testing methods, result findings and their conclusion is studied. Benefits of bio-diesel, possible ways to use bio-diesel and future scope through development of bio-diesel is studied for further research work.
**Keywords:** Biofuel, Biodiesel, Blend, Engine, Non-Edible Oil.

[a]. Research Scholar, MCOERC, Nashik;
[b]. Research Guide, MCOERC, Nashik;

## INTRODUCTION

### 1.1 Energy sources and their demand in India:

India has a significant presence on the international stage. After the People's Republic of China (hence referred to as "China"), it has the second-highest population in the world, and by the 2020s, it is expected to overtake China as the most populous nation. The world's fifth-largest economy in nominal terms, after the US, China, Japan, and Germany, has been seeing some of the strongest economic growth in recent years. India is the third-largest economy as measured in terms of purchasing power parity (PPP), which takes into account the purchasing power of Indians in comparison to those of other nations. With a PPP per capita income less than half of the global average, India is still a low-income economy. India has potential to grow very rapidly with the help of only half population of India under the age of 25. [3]

In India, the demand for energy services has enormous potential for growth because of the country's increasing economy and the forces of urbanisation and industrialization. However, there are substantial uncertainties over how demand growth will be satisfied. In general, India is resource-constrained, with the significant exceptions of solar, coal, and wind. The affordability of energy is a significant problem in India because of its extremely dense population, relatively high levels of water stress, land use restrictions, structural poverty, and other socioeconomic variables. [3]

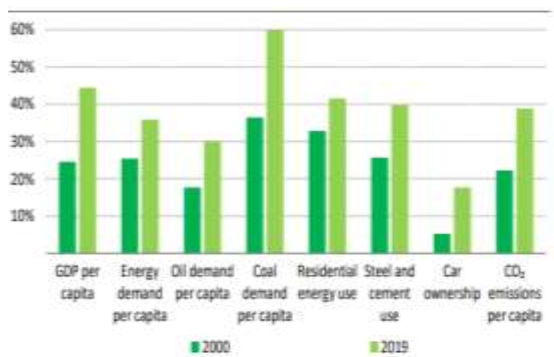


Fig.1 Key energy and economy indicators of India

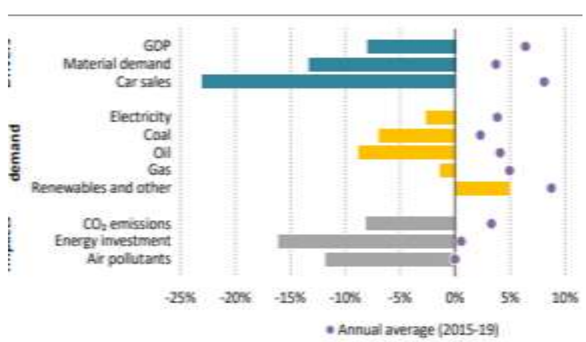


Fig. 2 India's Development Trajectory showing Impact of Covid - 19

#### 1.1.1 Energy requirements in Transport:

Indians are increasingly travelling farther than ever thanks to a booming economy. Indians now travel about 5,000 kilometres annually on average, a threefold increase since 2000. [3]

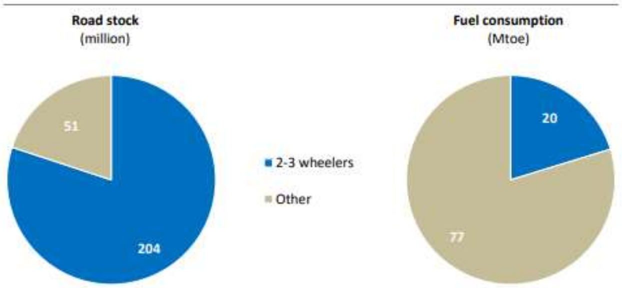


Fig. 3 India's Road Transport Utilization and Proportion of Total Energy.

For all new vehicles sold beginning in April 2020, the government has mandated the leapfrogging of vehicle fuel norms from Bharat Stage IV to Bharat Stage VI. This standard adheres to Euro 6. The Ethanol Blended Petrol (EBP) programme was introduced in 2003 with the goal of blending an average of 5% ethanol into gasoline, but it ultimately fell short of this goal due to issues with the supply chain and procurement as well as a lack of competitive pricing.[3]
With the approval of a more comprehensive National Policy on Biofuels (NBP) in 2018, a target of 20% ethanol in petrol and 5% biodiesel in diesel by 2030 was set (MoPNG, 2018). [3]

Using the enormous amounts of organic waste produced by the agricultural sector, as well as the rising amounts of municipal solid waste, wasted cooking oil, and wastewater, India has considerable potential to expand its modern bioenergy sector. There are a variety of supporting policies, some of which have been enhanced recently, most notably increased targets for biofuel blending and strategies to increase India's infrastructure for bio-compressed natural gas. [3]

**1.1.2 Demand of Oil in Transport Sector:**
India has experienced the second-highest growth in oil demand for road freight transport behind China since 2000. Trucks are responsible for more than 45% of road transport-related emissions in India. India is large Compared to other nations, freight vehicles consume a disproportionately high amount of gasoline per tonne kilometre, although the implementation of new engine specifications in 2020 should assist to lower the intensity of emissions-producing activities in the future.

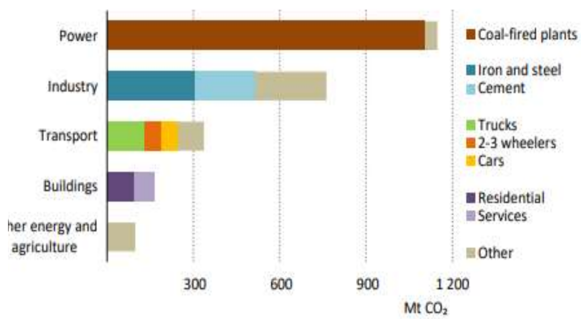


Fig. 4 India's power sector contribution to CO2 Emissions

By 2030, there are a number of specific goals to be met, including 450 GW of renewable energy capacity, a 15% natural gas share in the main energy mix, a 30% share of EV sales, and a 20% biofuel blend in petrol. [3]

**1.2 Need of Biodiesel:**

Another factor influencing companies and academia to develop and modify fuels and engines is the depletion of fossil fuels. The two main issues that need to be addressed are cutting back on harmful emissions and ending reliance on fossil fuels. Additionally, exhaust gas emissions have a significant impact on recent climate change, necessitating the use of alternate and renewable fuels like biofuel. Although it is technically possible to use 100% biofuel in diesel engines, there are some barriers to doing so, including a lower cetane number (CN), heating, and a greaterdensity value. The use of biofuel blends in diesel engines has therefore been introduced. [17]

**1.3 What is Biodiesel?**

A sustainable, biodegradable fuel made domestically from vegetable oils, animal fats, or used restaurant grease is called biodiesel. The Renewable Fuel Standard's biomass-based diesel and total advanced biofuel requirements are both satisfied by biodiesel. A domestically generated, clean-burning, and renewable alternative to petroleum diesel is biodiesel. The use of biodiesel as a vehicle fuel boosts energy security, enhances the environment and air quality, and offers safety advantages. The cetane number of the gasoline is increased and improved by the use of biodiesel. Technically speaking, biodiesel is superior than normal diesel. Biodiesel has the power to lower emissions while increasing lubricity and cetane number (CN). [16]

Biodiesel can be produced mainly from oil containing methyl ester or fatty acid chains.. Biodiesel produced from plants use either edible oil seeds or non edible oil seeds to extract oil from seeds. Considering world edible oil requirements, this is not feasible for many countries to use edible oil as a primary source for production of biofuel. Still, seeds can be used for production of edible oil are sunflower seeds, soyabean seeds, etc. these oils can be used for blend preparation of biodiesel. Another type of seeds used for extraction of oil are non-edible seeds. Those type of seeds have vast scope for research to get into environment friendly as well as economical use of such non edible seeds. According to studies more than 400 species of non-edible oil seeds.

In this paper we will study about the need of biodiesel, availability of biodiesel, sustanability of biodiesel, and current developments in the area of biodiesel.Biodiesel derived from plant oil or animal fats consists of mono-alkyl ester chain of fatty acids.synthesis process of biodiesel from triglyceride present in vegetable/ plant oil is derived from triesterification reaction with alcohol. This process is done number of steps untill alcohol gets converted into ester and glycerol. Biodiesel shows good physical and combustion properties like high density, viscosity, cloud point and octane number also lower volatability and heating value compared to exisiting diesel grades. Biodiesel blending is done to make it as useful in traditional diesel engine without any modification in engine. [20] Considering classification of biofuels, author explained about first generation and second generation biofuels in his paper.Vegetable oil, sugar, starch, etc. are the sources of first-generation biofuels. Whereas 2$^{nd}$ generation bio-fuels are derived from sustainable feedstocks. [21] Considering current scenario and environmental wastages, author studied about the vegetable oil, waste oil, animal waste, plant waste, municipal residue for preparation of biodiesel. Also, study continued with biodiesl production from animal waste like fish oil. [22] After studying advantages as well as disadvantages of biodiesel, author explained in his paper about biodiesel properties. Positive attributes include renewability, carbon neutrality, decreased hazardous pollutant emissions, and improved lubricity of blended fuel. However, biofuels also have drawbacks, such as high NOx emissions, high production costs, and poor oxidation stability.[23]

Biodiesel has taken more attention over petrodiesel. It has basic technology which treat alcohol with fats or oil in presence of catalyst. Catalyst used maybe acidic, alkaline, or enzymatic and used for synthesis of monoi-alkyl ester. For production of biodiesl low quality feedstock can be used without affecting the quality of biodiesel produced. Lower free acid containt is recorded for the proper formation of triesterification process which shoul be reduced to $< 1\%$, which is again comparable to 1 mg KOH/g of potassium hydroxide. [25]

**1.4 Nomenclature System in Biodiesel**:

Nomenclature for biodiesel fuel is given in alphanumeric arrangement, eg. B10, B12, B20,etc. in which, B stands for biodiesel is a chemical composition of diesel and another fuel. And number followed by alphabet B respresents % addition of biofuel added in diesel. If abbreviation consists of E, then E stands for ethanol contain in the fuel. [1]

**1.5 Catalyst Preparation:**

Author prepared catalyst from banana peel and methanol upto 99% purity. Waste banana peel collected and chopped into small pieces for experimentation. They are dried in the sunlight for a one day. With the help of blender dried peels are pulverized and burned to make it Ash. During combustion process the carbon formed was separated from the ash prepared from banana peels. The combustion process is carried out at different temperatures and reaction time and calcinied the ash in a furnace. The process carried our for 4hr reaction time at 500 oC temp, 5hr reaction time with 600 oC temp and 6hr reaction time with 700 oC temp. After the completion of calcination process, the formed catalyst is stored in air tight descicator. Further, characteristics are checked with the help of XRD. Calcination time increases yield of biodiesel decreases. [4]

## LITERATURE SURVEY:

**Types of Biodiesel :**

As researcher worked on different kinds of plant seeds, animal wastes and oils for production of biodiesel. We will shortly take a review on the same. M. V. Rodionova & et al discussed in their paper about the challenges and opportunities of biofuels like algae and microalgae. Author have classified the biofuel according to the 1st, 2nd & 3rd Generation. Fossil energy poses ongoing environmental risks despite rising global energy demand. Fossil energy consumption harms the environment and is likely to increase dramatically. The worldwide energy problem has garnered attention. Renewable energy is essential for global energy security. Biofuels are a great sustainable energy source that reduces fossil fuel use. Large-scale photosynthesis increases plant and algae growth utilising atmospheric carbon dioxide. Thus, photosynthesis-based biofuels might supply energy needs in an environmentally responsible and cost-effective manner. Isocitrate dehydrogenase overexpression and glutamate synthase deletion may boost ethylene synthesis in E. coli. Synechococcus sp. PCC 7002 generates alkane when heterologous acyleacyl carrier protein reductase and aldehyde decarbonylase are expressed.Microalgae that produce biofuel require the right amount of light, heat, nutrients, salinity, and pH. Stress on the environment boosts the production of biofuels while decreasing biomass output. Biomass buildup and biofuel production must balance. [15]

1. Vegetable Oil : DB Jani read research papers on using various kinds of biodiesel as an environmentally friendly fuel for internal combustion engines. Vegetable oil has a lot of potential as a sustainable energy source because plants may grow year after year. Due to the absence of toxic sulphur, they are referred to as a source of green energy. The high viscosities of such fuels are the fundamental issue with using vegetable oils in diesel engines. The use of vegetable oils in diesel engines typically results in greater CO, HC, and PM since the combustion time needs to be adjusted. Vegetable oils, however, reduce NOx emissions because of their slower combustion and lower combustion chamber temperatures. Vegetable oils are an alternative fuel, but they will still carry inherent hazards that neither manufacturers of automobiles nor agricultural equipment and machinery are ready to accept. The results show that using vegetable oil to make biodiesel is a good alternative to using regular diesel fuel because fossil petroleum resources were only discovered for a short time. [6]

Biodiesel synthesis: palm oil is synthesized in usable form by transesterification reaction and with the addition of 2% wt of catalyst. Catalyst used was calcinied ash prepared from banana peel. Reaction for biodiesel synthesis was carried out in a flask with 20 g of palm oil, 2wt % of catalyst and methanol (99% pure), at 65 oC and reaction time required was about 90min. [4]

**2.** Jatropa: Vineet Kumar Singh, et al explained about vegetable oil from non-edible oil which have added strength to the research area of biofuesl. The biofuel production got attention after facing internation oil crisis, growth momentum (1990s), and movements started towards reduction the dependence on imported oil as well as reduction of $CO_2$ emissions. Also, with the study of Jatropha author reflected a wide future research area for work. [5]

Author find jatropa seed fruitful for experimentation. And collected the jatropa seeds in a collector. To separate the jatropa kenel from seed coat researcher dried the seeds in an oven with 40 - 50 oC about 2hr time period. Oil extracted with a single screw mechanical extractor and properties required for blend are investigated. The process of esterification is compeleted in presence of homogeneous catalyst basic sodium hydroxide. Blend prepared with B10 and B20 are used for experimentation, where high specific fuel consumption was recorder during start up. Also, specific fuel consumption is decreased with the increase in blend percentage due to high viscosity of biodiesel, also said by the author. [12]

3. Argemono Mexicana: Researcher worked on argemono mexicana when used for biodiesel, followed process of triesterification to convert oil into ester. Blends prepared with the mention seed shown 11% less heating value than conventional diesle fuel. BTE found to be decreased as blend percentage has increased with the poor atomization of fuel. Biodiesel blends have better combustion so, higher blends shows less $CO_2$. [12]

4. Crude Palm Oil: Researcher converted the crude palm oil into biodiesel by achieving otpimum temperature as 315 oC, in presence of NiMo/$Al_2O_3$ catalyst. This gives yield of 68.2%. properties of palm crude oil checked and compared with diesel, found satiesfies properties like density of 0.8101gr/ml, kinematic viscosity as 4.27cSt, flash point 58 oC, cetane number as 75 and CV is 10693 cal/g. [13]

5. Cockelbur: Cockelbur is easy gowing and everywhere available plant, which don't need any specific type of soil ad envirnmental conditions. Readily availbility is a positive side of this palnt seed to use as a biofuel. [24]

6. Fih Oil: fih oil itself is vailable in different varieties and thus having larger area avalable for research. Every type of fish contains different quantty of fatty acid and thus shows different chemical composition of properties for preparation of bio-fuel. High number of short fatty chain is useful for preparation of oil blend at low temperatures too. And salmon fish showing maximum number of omega - 9 acid chains for the production of bio-fuel which is found advantageous for further research work. [26]

## Materials and Methods:

**Methodology:**

Methodology: In the mentioned paper number 1, experimentation carried on commercial 3L, four cylinder CI engine. Set up consists of CRDI injection system, ECU unit, etc. 107 kW is the maximum output power calculated at 3600 RPM and equivalent torque was 294 Nm. EGR system is implemented to reduce the emissions. Blends mentioned by author are B10, B20, B100, B10E5, B10E10, B20E5, B20E10, B100E5, B100E10, etc. physical properties of blended fuels have checked and calorific value is measured with the help of atomic bomb calorimeter. [1]

Whereas Kuntang Winangun et al, in their paper performed research work with Engine set up consists of single cylinder, four stroke diesel engine is used for experimentation. Water cooling system is run at 2000rpm around the engine. In this setup, separate manifold is provided to add hydrogen gas into the fuel before entering to combustion chamber. Gas intake is supplied with help of ECU at constant with combustion duration of 7ms and BDC angle of $0^o$. hydrogen gas supplied to water trap changes its pressure from 150 bar to a bar with the help of regulator. Fuel used for experimentation was palm oil + hydrogen gas (supplied at 2.5, 5, 7.5, and 10 lpm resp. As a dual fuel. [2]

In this paper, author performed experimentation was done on cottonseed oil and an isopropanal reagent also used as a hydrogen donor for the reaction. Partial hydrogenation reaction was carried out with heterogenous catalyst as it is available at low cost and can be easily separated from the oil. [2]

Another scientist used rapeseed to make biodiesel, which was made with rapeseed oil, which contains 60% oleic, 20% linoleic, and 4.5% palmitic acids, respectively. Because rapeseed oil has a lower acidity than other oils, transesterification was used right away to produce biofuel. The premeasured silicon dioxide nanoparticle concentrations of 0.1%, 0.2%, and 0.3% were dispersed during a 40-minute period in biodiesel blends using an ultrasonicator at a frequency of 36 kHz. [9]

**Nano additives in biodiesel :**

Influence of Nano-additive on the Performance of Diesel with Rape Seed Oil as Bio-Diesel was discussed by Satyanarayana Tirlangi et al. They had discovered a variety of non-food crops, such as mungbean, henna, flax, groundnut, flaxseed, jatropha, subcontinental marijuana, horchow, tangerine, and latex kernel, that might be used to produce biofuel. In a study, mahua oil-based biofuel is employed as a diesel replacement since it has roughly the same mineral content as other nonconsumable oils. Because of the fuel's higher absolute viscosity, moringa oil has been used straight as biofuel in a cylinder, which leads to lesser fuel atomization, detonation and the formation of soot deposits, engine fouling, and lubricating fluid infiltration.

The features of biofuel are enhanced, the burning rate is increased, and the emission levels are decreased when nanoparticles are added [25, 26]. Furthermore, the addition of nano-additives to diesel lowers particle emissions, lowers oxidising temperatures, and raises NOX levels in exhaust. The nano-SiO2 particles were used as a nano-additive in the biodiesel that contained rapeseed oil in the current study at concentrations of 0.1%, 0.2%, and 0.3%. [9]

By doping TiO2 nanoparticles (50 ppm, 100 ppm, and 150 ppm) and altering the fuel injection pressure, S. Padmanaba Sundar et al.'s study evaluated engine performance and came to the following conclusions:

• The cetane and calorific value of WPO (made from used food containers) were improved by doping TiO2 nanoparticle. The best concentration of nanoparticles for improving engine performance was discovered to be 150 ppm.

• When compared to diesel and neat WPO fuels, the BSFC decreased by approximately 4.35% and 15.38%, respectively, with a fuel injection pressure of 230 bar and the addition of TiO2 nanoparticles.

• The engine BTE rose when TiO2 nanoparticles were added to WPO fuel. In more detail, higher BTE was obtained for 150 ppm at 230 bar FIP, which was 2.5% higher overall than diesel and 14.5% higher than plain WPO.

• For WPO + 150 ppm TiO2, decreasing the fuel droplet size from 210 to 230 bar allows for faster vaporisation, which shortens the ignition delay. The in-cylinder pressure thus rises to 61.5 bar, which is 6% more than diesel. Additionally, a high dose of nano in the fuel discharges more heat due to the high surface area to volume ratio.

• Deep spray penetration caused by enhanced FIP of 230 bar and nano additions formed from oxygen in WPO lead to stronger oxidation, which results in reductions in HC and CO of 36% and 9.4%, respectively, over clean WPO and closer results compared to diesel.

• At 230 bar of FIP, the TiO2 blended WPO dramatically reduced smoke emissions. Due to the fine spray distribution inside the cylinder and the high oxygen levels, NOx emissions increased by 36%. Overall, it was determined that overhauling the engine's emissions, combustion, and performance while also adding 150 ppm of TiO2 nanoparticle to WPO resulted in a slight rise in NOx. This was accomplished by raising the fuel injection pressure to 230 bar. Therefore, WPO 14 might serve as an exact replacement for diesel fuel in stationary diesel engines. However, more investigation is required to assess its potential for long-term NOx reduction. [8]

## Experimental Setup:

Experimental setup: commenting on experimentation, researcher experimented performance of CI engine powered by biofuel with the help of dynamometer, experimental setup ran at 56Nm, 84Nm, 140Nm and speed also varied as 1000rpm, 1500rpm, 2000rpm. Crank angle encoder measured real time crank angle. Whereas, Bosch smoke intensity meter Okuda DSM 240 is used to measure smoke intensity. Also to visualize soot SEM is used. [1]

**Pressure data processing:**

Data received from pressure sensor and crank angle sensor is stored for approximately 1000 cycles with the help of DEWSOFT DAQ system. Among 1000cycles, 200 acceptable cycles were recorded and average of that considered as final cycle for more accurate results.

Experimental data analysis: weight scale and timer method is used to measure fuel consumption. Indicated work, brake work, friction losses and pumping losses, input heat energy, thermal efficiencies, etc. are calculated. [1]

**Experimental work :**

A Kirloskar four-stroke single-cylinder diesel engine with water cooling was put through tests. It is clear that adding nano-SiO2 particles to fuel mixes significantly increases the engine's overall power ratings and braking power. Additionally, the increased surface area of SiO2 nanoparticles considerably aided in the combustion of bio-diesel mixers and increased the engine's output power. It might be justified on the grounds that the SiO2 nanoparticles improved the reactive contact area, improving the efficiency of fuel combustion and lowering 13CO generation. The biodiesel containing 0.2% nano-SiO2 particles had the lowest CO and HC emissions, with respective values of 29.55% and 27.63%, and the highest braking power of 8.49 kW. The NOx emissions rose as nano-SiO2 concentration increased.

However, biodiesel with a 0.2% nano-SiO2 content showed somewhat lower NOx emissions. The 0.2% nano-SiO2 particle fraction in the biodiesel blend produced the best results. [9]

In this paper author worked on cockelrburr plant seed in which 35% of oil content was discovered, also xanthium species can show upto 42% of oil content, which is on higher side. Acid chins present in cocklebur oil was analysted and listed by researcher. High phosphourus contnt, cetane number and kinematic viscosity found at 70oC have shown good physicochemical properties for blnd preparaion. And thus, easily growing and everywhere available plant seed of cocklburr can beused for biofuel preparation. [24]

## Results and discussion:

Rresults were discussed for biofuels those are categorized in 4 groups. Group 1 as B10, B20, B100; group 2 as B10, B10E5, B10E10; group 3 as B20, B20E5, B20E10; group 4 as B100, B100E5, B100E10, etc. [1] combustion pressure increases with increase in load, and for the same air fuel mixing time is decreased. Ethanol blended fuels shows higher combustion pressure with increasing graph for increased value of ethanol than that of without ethanol blended fuels. And so combustion efficiency increases. Longer ignition delay because of higher values of auto ignition temperature, heat of vaporization and lower value of ethanol. So, it is concluded that ethanol blended fuels can feed higher MPRR, NHRR and in-cylinder pressure. [1]

Combustion characteristics: results are discussed about an investigation done on mono fuel as well as DDF engine generating on dual fuel as hydrogen gas and palm oil based biodiesel. [2] Conclusion: lower calorific values results in higher fuel consumption of ethanol blended fuels but thermal efficiency increases and smoke emissions are also reduced. Cylinder pressure shown lower values for DDF engine when compared with mono-fuel engine. Highest heat release is observed on dual engine when hydrogen flows at 7.5 lpm at low load when compared with mono-fuel engine. Ignition delay: ddf engine shows longer ignition delay at 10 lpm when compared with mono fuel engine. Also, ddf shows smaller ignition delay with 2.5 lpm flow of hydrogen in DDF engine. In such case of shorter ignition delay, biodiesel can not be burned. Less knocking sound is produced by mono fuel engine compared to DDF.

Engine performance: mono fuel biodiesel shows 0.9% of less power readings than bi-fuel with actuating maximum hydrogen flow. Also, brake thermal efficinecy which is the best measure of an IC engine, is increased by almost 53% with hydrogen gas flow at 10lpm than compared with mono-fuel. Study of this paper reveals that. Fuel consumption is reduced by 47% and engine efficiency is increased by 27% with use of hydrogen gas in DDF engine than that of mono fuel engine.[2]

In this paper, results characteristics of catalyst are discussed by author. Presence of magnesium, potassium and calcium content was found in the banana peel catalyst. Potassium is useful for biodiesel transesterification process and it was evidenced by the formation of methyl ester in the reaction. Results of XRD analysis showed that banana peel catalyst observed with oxides like K2O, CaO, Na2O and MgO. FT-IR functional group analysis is used for the determination of type of chemical bond present. IR wavelengths present in the sample reveals following results as; 883, 1032, and 1122 cm-1 shows presence of K-O strain vibrations, 617 and 1663 cm-1 are because of symmetric and asymmetric strain vibrations caused by Ca-O, likewise. [4]

Author concluded with the results of experimentation as blending hydrogenated biodiesel, ethanol and diesel can reform fuel with better properties like oxygen content, cetane number, kinematic viscosity etc. Also, author published in this article that, ternary blends had improved distillation temperatures as well as activation energies when compared with binary blends. So, ethanol addition to blend can show better volatisation characteristics and kinematic viscosity. [7]

G. How & et al tried an experimentation on biodiesel & .H this research concludes as follows. B20E5 and B20 have greater BSFCs than diesel. B20E5 has 2.0-2.7% greater BSFC than diesel fuel at all engine loads. B20 and B20E5 BTE exceeds diesel. At medium load (BMEP = 0.69 MPa), B20E5 outperforms diesel by 5.4%. B20 and B20E5 fuel blends reduce smoke and CO emissions independent of load. Ethanol blends reduce NOx emissions under all loading conditions. At 0.17 MPa load, the B20E5 has lower peak pressure and peak HRR. Ethanol's cooling impact reduces peak HRR during premixed combustion, lowering NOx emissions. Productivity matters. [18]

M. Auti, et al. clarified in conclusion that the usage of tyre .S pyrolysis oil can be highly advantageous due to higher sulphur content and higher exhaust emission restrictions. The researcher concentrated on oil blends made from pyrolysis and also provided a parametric comparison between that oil and biofuel. For testing, the researcher created a blend known as TP10KB20, TP20KB10, and equivalent source blend (TPO30, KBD30, and diesel) fuel with tyre pyrolysis (TP) 10%, karanja biodiesel (KB) 20%, and diesel 70%. Performance analysis, combustion analysis, and emission analysis of the engine were performed during the experimentation. Diesel, TP20KB10, and BTHE are measured at 26.11%, 27.67%, and 27.06%, respectively, at full load. [19]

Extraction process: palm is extracted from POME, malsia. Large quantity of waste palm oil first collected in large quantity collectors. Oil extraction process is done with N-hexane type solvet. Centrifugal stirring is done at 500rpm at 40 oC temp and for 25min. With this process 90% of RPO was extracted from POME.

Experimental investigations: triesterification reaction is performed in three steps to extract biodiesel from palm oil. First of all, triglyceride is converted into diglyceride, then diglyceride is converted into biglyceride and at last diglycerides are converted into monoglycerides, monoglycerides are converted into fatty acid methyl esters to get the end products as biodiesel and glycerol. Later on author conducted alcoholysis with conventional heating system. In a reactor, oil and solvent are pumped and stirred with stirrer at constant rpm. Also, reactor temperature is monitored and kept constant with the help of controlling valve. This process was carried out at rection temperature as 3070 oC and reaction time as 15 hr. After 3hours of settling time, 3 layers are obtained as first layer of solvent, middle layer of biodiesel and last layer of glycerol. Catalyst used to support the reaction was KOH, and at end of reaction an equal amount of biodiesel and alcohol was recorded. [10]

In their study, Bobade S.N. (5), et al. described how to prepare methyl ester (biodiesel) from karanja (pongamia pinnata) oil. Biodiesel is a long-chain fatty acid mono-alkyl ester that is made from renewable biological sources. It is suitable for direct use in engines with compression ignition. Vegetable oils can be used neat, however it is not recommended, according to studies1. Vegetable oils have a high viscosity and a low volatility, which affects how the fuel atomizes and sprays, causing severe carbon deposits, incomplete combustion, injector choking, and piston ring sticking. Emulsification, pyrolysis, transesterification, and blending with diesel are techniques used to reduce viscosity.

The most popular commercial procedure for creating clean, environmentally friendly fuel is transesterification.2 Methyl/ethyl esters of rice bran oil, palm oil, mahua oil, jatropha oil, karanja oil, soybean oil, rapeseed oil, and rubber seed oil are also available.13,14 have undergone successful C.I. engine testing, and their performance has been investigated. Due of its accessibility and affordable manufacturing, non-edible oils like karanja (pongamia pinnata) are appealing. In contrast to biodiesel made from jatropha curcas, which has a small corrosive effect on the piston liner, biodiesel made from karanja oil exhibits no corrosion on the piston metal and liner. Methyl esters are formed under low pressure and low temperature circumstances and are non-corrosive.

In the current experiment, karanja oil was used to make biodiesel, and its qualities were examined to determine its appropriateness as such.

Reaction to Transesterification

| | | | |
|---|---|---|---|
| | | Using the catalyst | |
| $CH_2OCOR'''$ | | $CH_2OH$ | $R'''COOR$ |
| $CH_2OCOR''$ | + 3ROH | $CH_2OH$ + | $R''COOR$ |
| $CH_2OCOR'$ | | $CH_2OH$ | $R'COOR$ |
| 100 kilos | 10 lbs. | 10 lbs. | 100 lbs. |
| Oil or Fat(1) | Alcohol (3) | Biodiesel(1) | Glycerin (3) |

Scheme-2

General formula for triglyceride methanolysis The author also came to the conclusion that karanja oils can be employed as a source of triglycerides in the transesterification reaction to produce biodiesel. In comparison to edible oils, it is less expensive and readily available. It took some modifications to change the process and boost the yield of ester for biodiesel to become a viable economic choice in India. [11]

In this paper, author concluded with benefits of bio-fuel as listed below:

1. Fuel is also used for stationary as well as mobile engines which are used for water pumping, transportation, lighting, heating, grain milling, etc.

2. Plantation of such non-edible seeds used for biofuel production can reduce poverty, also specially women not working in rural areas can make money from this plantation.

3. Environment improvement is also possible through reduced erosion, improved soil fertilifty, GHG mitigation, etc.

4. Reduced combustion of firewood can help to reduce deforestation.

5. An increased GDP and reduction in import of fuels is possible. [14]

## CONCLUSION

As per the review of different research papers, following conclusions have made:
1. bio-diesel is found an efficient source of fuel.
2. Energy sector is also showing fast growth and huge research area in the field of bio-fuels.
3. According to latest worldwide energy scenario, bio-fuel production can replace larger energy demand for road transport before 2040.
4. Different non-edible species and animal waste can be used because of an availability of feedstock in abundance.
5. Emission control can be done with the help of reduction in CO2 after using bio-fuels which is proved by many researchers in their research work.
6. Different methodologies and experimental setups are used according to availability of feedstock but any modification in existing diesel engine is not needed.
7. Performance characteristics of bio-fuel/bio-diesel showing almost same or nearby performance results when compared with diesel engine.

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