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Research Paper

Production and Comparison of Yields of Biodiesel from Food Waste and Cheap Sources to Identify Good Raw Material in India for Replacement Present Diesel Fuel

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Abstract— Particulate matter is a significant environmental threat because of its link to fossil-fuel-induced climate changes and harmful carbon dioxide emissions. The purpose of this research is to use food waste products and used cooking oil to power human needs while minimizing environmental damage. Using biofuel can help us protect the environment, reduce carbon dioxide emissions and reduce transportation cost as biofuel is substitute of petrol and diesel. We investigate waste-to-energy (thermal and biochemical) conversion techniques. The primary focus of this research is on advances in the field of "synchronous waste mitigation with energy development." In this article compares the yield of biodiesel production by using various raw materials. This research is conducted to finding quality raw materials which available easily in India for biodiesel production. Emphasizing the significance of organic molecules in the creation of cleans and renewable energy. The necessity for adequate and renewable fossil fuel alternatives is emphasized.

Keywords— GHG (Green House Gas), CO_2 (Carbon dioxide), EPA (Environmental Protection Agency), WVO (Waste Vegetable Oil), PPO (Pure Plant Oil), SVO (Straight Vegetable Oil), WCO (Waste Cooking Oil), FFA (Free Fatty Acid), FAME (Fatty Acid Methyl Ester).

1. Introduction

Biofuels are gaining popularity. They are a type of renewable energy derived from biomass, which is organic matter produced continuously by plants and other organisms and may be grown and harvested. Agriculture, crucial harvesting, forests, and waste streams are all used to produce biofuels. They are used to replace nonrenewable sources of energy. Some of the most prevalent biofuels are biodiesel, bioethanol, and biogas. Oils from plants, reclaimed wax, or animal fats are used to make biodiesel. Bioethanol is produced by distilling sugar and starch-containing plants, such as corn. The energy contained in petroleum oil is critical. The transportation industry consumes more than 70% of the world's petroleum fuel.

When petroleum fuels are utilized in excess, they emit GHG such as CO_2 as well as other hazardous gases. This causes people to be concerned about their health and global warming. People's activities will have added more than 43 billion metric tons of CO_2 and other GHG_s to the atmosphere by 2040. Biofuels are being researched and developed as an alternative fuel due to their renewability, low environmental effect, and potential to replace petroleum. Based on the feedstock, biofuels fall into the category of either "first generation," "second generation," "third generation," or "fourth generation". Biofuels include fuels that are solid, liquid, and gaseous. Certain biofuels can replace conventional fuel sources and reduce carbon emissions; they are produced from biomass feedstocks. Conventional biofuels relate to the first generation of biofuels, whereas modern biofuels refer to the second and third generations, both of which are distinguished by differences in the feedstock used and the production techniques employed.

Biodiesel is environmentally benign and well-liked worldwide; biodiesel is a fuel that has attracted. It is an inexhaustible, biodegradable, and harmless fuel. Biodiesel has grown in prominence recently, but it also has several drawbacks. When comparing biodiesel to petro diesel, more biodiesel is needed. The following discussion includes a few benefits and drawbacks.

1.1 Advantages of Biodiesel

This fuel has a lot of benefits. The EPA claims that biodiesel degrades four times more quickly than regular diesel fuel. Additionally improving energy security, biodiesel lessens reliance on foreign oil imports. It functions as lubricant, assisting in the removal of debris from the engine that could clog it and result in engine failure. Biodiesel is safer, non-toxic (10 times less toxic), and has a higher flashpoint. Because it burns at a high temperature and is therefore less likely to create an accident due to combustion, transportation and storage are made simpler.

1.2 Disadvantages of Biodiesel

Some of the main drawbacks of biodiesel commercial diesel fuel have a higher torque value than biodiesel. Compared to traditional diesel fuel, biodiesel also has greater specific fuel consumption values. When compared to diesel fuel, biodiesel likewise has lower efficiency and effective pressure values. Some of biodiesel's major limitations when compared to petro-diesel are its operating circumstances. Biodiesel produces little power at low speeds and uses most of its fuel to overcome engine friction, its fuel consumption drops at low speeds and increases as speed increases.

1.3 Need of Biodiesel from Waste

The problem of using fossil fuels and the emission of CO_2 may be reduced with the use of biodiesel made from waste materials or renewable resources. Additionally, it lessens reliance on imported petroleum. Due to the high demand for gasoline and diesel fuel, our transportation sector completely depends on petroleum for energy.

Additionally, it aids in lowering health-related issues including air pollution. Our primary goal, according to the EPA, is to lower the danger of environmental pollution to the public's health. Air toxics are just a few of the air pollutants that biodiesel helps to lower emissions of. The Indian economy loses money as a result of petroleum imports from other nations. By providing energy for our nation and bringing new energy production technology to market, biodiesel will aid in the growth of the Indian economy.
In this research the biodiesel is produced by using two raw materials WCO and food waste.

Cooking oil contains trans-fatty acids which increase on reheating. Trans-fats are worse than saturated fats. Because they not only increase the bad cholesterol level but also reduce the good cholesterol level. Due to reusing of cooking oil problems like Parkinson’s disease, heart disease, stroke cancer and various liver problems can increase. Re-heating the oil makes it carcinogenic Carcinogen is an agent that causes cancer. According to research, when oil is repeatedly heated, aldehydes (poisonous elements) are produced in it. So if we use WCO for biodiesel production it also plays an important role in our health. So reusing of cooking oil is very dangerous.

2. Related Work

REVIEW OF LITERATURE

2.1 HISTORICAL BACKGROUND ON BIODIESEL PRODUCTION

In internal combustion engines, vegetable oils have been used as liquid fuels for the first time in 1900 when Rudolf Diesel employed peanut oil. However, there have occasionally been shortages of petroleum and the fuels made from it, which has led to an increase in interest in alternate energy sources. Different triglycerides were pyrolyzed at the time to offer liquid fuel to various nations. WVO and PPO are the types of vegetable oils that are most frequently employed in trans-esterification reactions (Knothe et al., 2001).

2.1.1 Straight Vegetable Oils (SVO)

No other firms or households produce SVO, hence they are considered to be PPO. While oils are frequently extracted from oilseed plants seeds, pure plant-based oils are significantly preferable.

2.1.2 Waste Cooking Oils (WCO)

Vegetable oil waste, often known as WCO, can be used as a feedstock instead of more valuable refined oils. Cheap and readily available used oil can be sourced from a variety of locations, including homes and restaurants (refine oils). Offers various benefits, such as reduced manufacturing costs and reduced pollution. To avoid environmental damage, these oils must be treated before being disposed of. Many people, especially in rural areas, directly dispose of used cooking oils in the environment due to the expensive cost of disposal. Encinar (2006) came to the conclusion that using used cooking oil can significantly lower the price of producing biodiesel.

2.2. Solvent

Sprules and Price (1950) define alcohol as a class of compounds consisting of the primary and secondary sources.

2.3. Catalyst

A catalyst is a material that lowers the reaction's activation energy to speed up the rate of the reaction. A catalyst was recovered unaltered, and the product does not contain it. Triglyceride trans-esterification catalysts fall into three categories: homogeneous, heterogeneous, and enzyme-based.

2.3.1 Homogeneous Catalyst

The employment of a homogeneous catalyst in a reaction requires that at least one of the reactants be dissolved in the catalyst the two main types of homogeneous catalysts (KOH or NaOH) (Duet al., 2004).

2.3.2 Heterogeneous Catalyst

Multiple phases are involved in a heterogeneous catalytic process, which typically contains a solid catalyst, and liquid or gaseous reactants and products. Benefits of heterogeneous catalysts include their ability to be engineered for increased activity, selectivity, and longer catalyst lifetime in addition to being non-corrosive, environmentally benign, and simple to separate from liquid products (Gryglewicz, 1999).

2.3.3 Enzyme Catalyst

A bio-catalyst called lipase is utilized instead of a chemical catalyst in another method of producing biodiesel. A bio-catalyst is a protein or macromolecule with protein-like capabilities, such as an enzyme. It accelerates the chemical transformation of a substrate (a reactant molecule) far faster than would occur without the catalyst.

2.4. Process of Synthesizing Biodiesel
Trasesterification can be used in a variety of alternative processes, such as hydrolysis, supercritical alcohol trans-esterification, enzyme catalyzed.

2.4.1 Direct Use and Blending
Vegetable oils should not be used directly in diesel engines since they have numerous flaws that make them troublesome. Even though vegetable oils contain characteristics that are similar to those of biodiesel fuel, they needed to undergo some chemical alterations before they could be utilized in engines. It has been experimented with for a century, but only recently has it been the subject of considerable research.

2.4.2 Thermal Cracking (Pyrolysis)
The term "pyrolysis" was coined by Sonntag (1979) to describe the transformation of one material into another with the application of heat (or catalyzed heat). Pyrolysis, the process by which small molecules are created, calls for the heating of materials while there is no air or oxygen. It is difficult to define pyrolysis chemistry since there are so many distinct reaction paths and so many different probable reaction products.

2.4.3 Transesterification Process
The high viscosity of triglycerides has been significantly reduced with this technique. The following equation uses the general equation to describe the trans-esterification reaction. One of the reversible reactions is trans-esterification, which mostly involves mixing the reactants. A catalyst, such as a potent acid or base, will quicken the conversion, though.

2.4.4 Lipid Extraction
Two straightforward and practical techniques for lipid extraction from untreated sewage sludge were created by Boocock et al. in 1992. According to the results, the boiling extraction process collects more fatty material. This approach is superior since it is independent of the level of nitrogen and sulphuric rejection.

Rapeseed oil was utilized to make biodiesel by Peterson et al. in 1998. Previous studies had demonstrated that trans-esterifying vegetable oil was a superior replacement for diesel fuel. Rapeseed oil trans-esterification was carried out using ethanol with a base catalyst like potassium or sodium hydroxide. Both glycerol and ethyl ester are produced, with glycerol being the heavier phase. Produced glycerol can be used in various sectors.

3. Experimental Method

Sample collection
Vegetables, fruits, and other goods are among the food waste that is collected from the Various College canteen. Hazardous waste is produced during the treatment of food waste. Both solid and liquid food waste samples were taken from the campus cafeteria for analysis. Vegetables, fruits, rice, and other food scraps, along with wastewater, make up about half of the 150 kg of garbage collected every week.

3.1 ANALYSIS OF FOOD WASTE
3.1.1. Drying Methods for Food Waste
A sample of regarding 5 kg of waste food trash was gathered from many colleges and other locations where food waste generation is common. In an airtight container, a total of 20 samples were gathered during peak research hours and brought to the lab for later processing.

Moisture in kitchen waste has been rid by the use of drying procedures such as oven drying, freeze drying, and sun drying. Given that food waste contains food particles and water, the most difficult aspect of making biodiesel from it will be correctly removing the lipids. Food waste contains up to 91-95% water, thus dewatering and drying it is required to make biodiesel, which is responsible for over fifty percent of the whole cost. As a result, removing the water from a food waste sample is a crucial procedure in the production of biodiesel and lipids. According to Olkiewicz et al. (2014) different drying techniques have been applied because the output of biodiesel and moisture content decrease with increasing drying temperature. Similar drying techniques have been used for food waste in order to determine the optimal temperature that will make it most practical to extract lipid for the generation of biodiesel. As a result, the sample was dried using a variety of drying techniques, including oven, freeze, and sun drying.

Table 3.1: Food waste drying methods

S. N.	Food waste drying methods	Temperature (°C)	Duration of drying (days)
1.	Oven drying	115	1
		70	2
		55	3
2.	Freeze drying	-4	2
3.	Sun drying	--	10

3.2. Lipid Extraction and Analysis
Following drying, the extraction was performed using Bleigh Dyer's technique and the Soxhlet apparatus as the solvent. Using a magnetic stirrer, researchers have examined the percentage using varying contact periods and ratios. After extraction, a rotary evaporator was used to remove the solvent at 70 degrees Celsius while maintaining a vacuum.

3.2.1 Liquid-Liquid Extraction
The food waste was extracted ten times in a row, each time with the addition of a new solvent after it had settled. After each step in the extraction process, the sample is passed through a sheet of whatman42 filter paper, 125mm to remove any remaining solids. The solvent is then extracted using a rotating evaporator at 70°C and under vacuum. The weight of the extracted lipids the day after they were dried in a desiccator allowed us to determine the extraction yield.

3.3. Biodiesel Production
Various trans-esterification techniques can make biodiesel. The value of the FFA determines how much trans-esterification occurs. Base-catalyzed trans-esterification is favored if FFA 1. As FFAs forms cleanser with base catalysts, feedstock should have a low FFA content although base catalysts create soap; they have a higher reaction rate

than acid catalysts. Catalyst deactivation and high production costs are caused by soap formation. Trans-esterification of FFA by acid catalysts results in the generation of biodiesel without the formation of soap.

Acid catalyst has drawbacks, such as delayed reactions and higher reaction temperatures. By producing biodiesel from inexpensive source materials, acid catalyzed trans-esterification reduces the cost of production. Base-catalyzed reactions happen 4000 times more quickly than acid-catalyzed ones. To determine whether the fatty acid methyl ester produced by trans-esterification fulfilled certain standards, it underwent analysis and comparison.

3.3.1 Catalyst Type, Concentration and Reagent

Researchers have discovered a large number of effective catalysts to speed up the reaction rate. Rearrangement is still possible when there is no catalyst, but only under specific temperature and time parameters that cause undesirable outcomes such isomerization, polymerization, and breakdown.

However, soap is formed when FFA and the alkali catalyst combine. This makes it difficult to separate the glycerol and reduces the amount of biodiesel that may be produced. There should also be more of a "catalyst." The raw materials and reaction conditions are frequently utilized to select the catalyst.

3.3.2 Trans-esterification of Food Waste

Acid catalyzed trans-esterification was used to trans-esterify food waste. Furthermore, free fatty acid methyl ester was not detected as strong peaks in the GC FAME study. A known volume of lipid was generated for this study in a flask with a circular neck and bottom. Methanol in a known amount and catalyst (H_2SO_4) were dissolved in a solution. Lipid was mixed with the solution, which was then sealed in an airtight flask. A heating base was used to keep the flask at 65 °C, which is near to the boiling point of methanol. Using a magnetic stirrer, the material was continually stirred for two to five hours. After the methyl ester had formed, the heating was turned off, and the product was allowed to cool before being transferred to a separatory funnel. For complete methyl ester and glycerol separation, the product was left undisturbed for 24 hours. Methanol and methyl ester make up the majority of the ester layer. By utilizing a rotary evaporator set at 75 °C, the methanol in the methyl ester was recovered.

3.3.3 Washing of Biodiesel

Biodiesel that has undergone trans-esterification must be cleaned to get rid of any lingering catalyst, methanol or other contaminants. Biodiesel's methyl esters are a key ingredient, but they often contain impurities that degrade the fuel's quality and must be isolated. Detrimental to biodiesel's quality, glycerol and glycerides are eliminated during processing. Washing biodiesel can be done wet or dry. Mixing biodiesel with purified water is known as "wet washing". Dry washing entails the addition of an adsorbent, such as resin, anhydrous sodium sulphate, or magnesol. After trans-esterification, wet washing of the biodiesel was done in this investigation. Another name for this wet cleaning technique is water wash method. Because it is the most traditional and popular washing procedure, the wet wash method has been chosen. The water used in the washing process can also be reused for irrigation after a brief purification process. Most other methods of garbage disposal result in hazardous wastes that are difficult to dispose of. Biodiesel that still contains unreacted glycerin, alcohol, or catalyst is washed in water to remove it. Furthermore, it will get rid of any soap that could be there. Try giving yourself a day to relax. Once the mixture has settled, the biodiesel will rise to the surface and float. Get rid of all the moisture. After washing, check the biodiesel's pH level; it should be around 7. Biodiesel may be cleaned up by being washed multiple times.

3.3.4 FAME Analysis

After washing, a gas chromatography-flame ionization detector was used to evaluate FAME (GC-FID). To identify each particular FAME in the product, a 37 component FAME mix standard was used. Table 4.3 provides a discussion of the FAME analysis programme. Following identification, the ASTM, European, and Indian standards for the manufacturing of biodiesel were compared to the FAME attributes.

Table 3.2: GC-FID program for FAME analysis

Col.	Agilent 122-5532E: 1 DB. 5ms 0°C - 335°C (350°C): 30m x 250µm x 0.25µm
Oven	140°C (6 min) to 245°C at 4 min
gas	N. (nitrogen)
Det.	FID
Inj.	1µl, 260°C, split 100:1
Sam.	Dil. to 1mg/ml in CH_2Cl_2

3.4. CHEMICAL EVALUATIOM OF WASTE PRODUCTS FROM LIPID EXTRACTION

“After lipid extraction, the leftover waste has been used for acid digestion. It is required to break down the sample of food waste in order to do a thorough chemical evaluation. In a digestion tube with 4 ml of HNO3 (65%), 2 ml of HF (40%) and 2 ml of H2O2, around 0.26 gm of samples of powder have been obtained (30 percent).

4. Results and Discussion

MOISTURE CONTENT AND LIPID YIELD

A crucial step in both lipid extraction and the creation of biodiesel is drying the sample of food waste and removing any moisture. Food waste samples may contain solid particles that are surrounded by water, which prevents the solvent from penetrating the solid particles. A sample's final moisture content is determined by how it was dried and how hot it was. Moisture content was found to be low at high temperatures. Table illustrates that the amount of lipids that can be extracted decreases as the moisture content of the sample increases.

Table 4.1: The impact of various drying techniques on extraction of lipid

S. N.	Methods of Drying	Tem.(°C)	Drying (hours)	Moisture content (%)	Yield of Lipid (%)
1.	Oven drying	105	24	0.1	37.3
		75	48	1.5	28.8
		55	72	2.4	25.4
2.	Freeze drying	-4	48	7.5	13.7
3.	Sun drying	25-30	240	4.6	16.5

Generally speaking, the amount of extracted lipids decreases with increasing sample moisture content. The procedures of sun drying and freeze drying take a long time and don't produce the greatest results. The sun drying method needs 240 hours to complete the drying process, depending on the weather. Food waste samples cannot be sun dried during the wet season. Additionally, it will emit a bad smell, impact the environment, and harm human health. Long fatty acid chains are also necessary for the manufacture of biodiesel. The carbon chain may break at temperatures above 105 °C, which will have an impact on the creation of biodiesel.

Table 4.2: Lipid yield and food waste composition

S. N.	Days	Food Waste Composition	Lipid yield % (weight of lipid/ dry weight of food waste)
1.	Mon.	Only veg.	33.5
2.	Tue.	Non-veg. as well as veg.	36.3
3.	Wed.	Non-veg. as well as veg.	37.8
4.	Thur.	Only veg.	31.2
5.	Fri.	Non-veg. as well as veg.	35.4
6.	Sat.	Non-veg. as well as veg.	38.3
7.	Sun.	Non-veg. as well as veg.	39.2

Table 4.3: Comparison of the current study's biodiesel production produced from various raw materials

S. N.	Raw materials	Biodiesel yield (%)
1.	Pongamia pinnata oil	75
2.	Waste cooking oil	66.10
3.	Waste cooking oil	81.05
4.	Wastewater sludge	51.39
5.	Sewage sludge	65
6.	Rapeseed oil	54.2
7.	Soybean oil	98.6
8.	Microalgae	84
9.	Jatropha oil	80.6
10.	Food waste	33.4

In this research, to produce biodiesel the raw materials used are waste cooking oil, soybean oil and food waste and the values which mention above is from my research. Remaining values and raw materials is taken from different research papers.

PROPERTIES:
Following the FAME study, the chemical and physical characteristics of biodiesel were assessed in order to compare them to ASTM, EN, and Indian standards. Table 4.4 presents the outcomes.

Table 4.4 Biodiesel characteristics compared to ASTM, EN and Indian standards.

S.N.	Properties	ASTM D6751	EN14316	IS 15547	Acquired value
1	Density at 15 degree C	875-900	860-900	860-900	874
2	Kinematic viscosity	1.9-6.0	3.5-5.0	2.5-6.0	2.3
3	Acid value	0.5	0.5	0.5	0.64
4	Pour point	- 3 to12	-	-	6
5	Calorific value	-	35	-	32.28
6	Metals(Na+ K)	5	5	-	1.4
7	Metals(Ca+ Mg)	5	5	-	1.35
8	Ash Content	0.02	0.02	0.02	0.0072

The density of biodiesel produced from food waste was determined to be 873 kg/m^3, which is acceptable by ASTM, EN and IS criteria. Biodiesel often has higher density than diesel fuel made from petroleum. Both their purity and fatty acid composition affect the values. Density can be decreased by low density pollutants like methanol or increased with a decrease in fatty acid chain length and an increase in double bonds.

5. Conclusion and Future Scope

The yield of biodiesel is very good by using soybean oil, good yield from WCO and average yield from food waste. Out of this WCO and food waste this raw material is available throughout in India. The yield of soybean oil is very good but we cannot use it as the prices of soybean oil is very much than diesel, we need cheaper alternatives. The yield of biodiesel from food waste is very low so this raw material is average. From this research it is concluded that used cooking oil is good raw material. The yield is also good 65 – 85 % depending on impurities in WCO. If we use this raw material then we also avoid lot of health related problems which is discussed above. But this raw material is also one drawback, nowadays the soybean oil price is gone very high the price is 70-75 rupees / lit but now the price is very high that is 140-150 rupees/ lit. So if we want to repurchase the used cooking oil then we need to offer approximately 50-80 rupees per liter then proceeding biodiesel cost, labor cost and profit margin approximately 15-20/ lit. If we purchase waste cooking oil on this price then biodiesel price is more than current diesel fuel. by calculating all this it is concluded if we produce biodiesel from WCO then price of biodiesel is 95-100 rupees per liter this price is same as diesel so if we need to cheaper fuel cost we need biodiesel price 40 – 45 rupees per liter for this we need to decrease soybean oil price or identify another good raw material which available easily in India.

Data Availability
none.

Conflict of Interest
Author declares that there is no competing interest in the publication of this article

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Authors' Contributions
Rajkumar Jajoo designed this research work and prepared the manuscript for publication. Author completed this research from PG tech research institute during dissertation to fulfill Master of Science degree.

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