

Preparation and Characterization of the Hybrid Biodiesel of Waste Cooking Oil and Cotton Seed Oil

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Biodiesel combined the ecological sociability, biodegradability, lower harmfulness emissions and renewability. The adaption of fixed transesterification process and recovery of high-quality glycerol from biodiesel byproduct (glycerol) are primary options to be considered to lower the cost of biodiesel. In the present study, Waste cooking oil & Cotton seed oil were analyzed and confronted with other literature sources. Critical parameters such as cetane number, viscosity, density, specific gravity, API density, acid value etc. are matched with ASTM Standards of cleaner biodiesel. The present study also found an increment in the cetane index to prepare the second-generation biodiesel fuel.

Keywords: *Biodiesel, Waste Cooking Oil, Cotton Seed Oil, Transesterification Process, Cetane Number.*

INTRODUCTION

From January 1972 to August 2017 crude oil prices rise exactly up to 75 to 80 times as it was traded with 1.85 USD where after June 2008, it crossed over 140 USD. As far as crude oil is a concern and taken on account of business and marketing the price may rise up drastically within 30-40 year. For any developing country, crude oil can be regarded as the “life-line” of its economy. The increasing dependency on Crude Oil, which also increases the emission of greenhouse-gases, is sustained, therefore, an alternative fuel is regarded as the reliable source of energy. Henceforth, Bio-Diesel is concerned as the focal point of the research.

Bio-fuels are less pollutant than conventional fuels, such as diesel, as emit a smaller amount of harmful chemical elements as emission and proved as a cleaner fuel. Utilization of the ethanol as one of the primary energy sources to fight the global warming by the reduction of the emission of carbon dioxide (CO₂). As an alternative fuel bio-diesel can be used in neat form or mixed with petroleum-based diesel. The utilization of the waste cooking oil instead of pure fuel to produce the bio-diesel is found as an efficient method to lower the cost of raw materials. And also using waste cooking helps solve the problem of wastage of oil disposal.

Bio-Diesel is composed of vegetable oils and fats. The calorific value of vegetable oil is compared to that of diesel additionally the viscosity of the vegetable oil is about ten times higher than diesel. Utilization of vegetable oils leads to poor fuel atomization, incomplete combustion and carbon deposition at fuel injector and valves results to faulty. So, in order to reduce the viscosity of vegetable oils, it is coalesced with diesel which is further processed by emulsification, pyrolysis, cracking and transesterification. Bio-Diesel has higher octane number

and contains 10%-11% oxygen by weight. These properties of bio-diesel leads to the lesser emission of carbon monoxide (CO), hydrocarbons (HC) and particulate matter[1].

It is estimated that the cost of bio-diesel is aboutRs. 50-100 per liter, which is almost one and half times higher than that of diesel, so in order to reduce the cost of bio-diesel waste cooking oil is utilized. This waste cooking oil reduces the cost of bio-diesel 60-70% [2, 3]. In India, cooking oil consumption per person is about 29 gm, so, as taken yearly roughly it goes about to 10.58 litres. According to Indian population count in India which is 1.324 billion approximately 14 billion litres [4]. Figure 1 presents the production of biodiesel from various feedstocks, such as cotton seed oil, jatropha, etc.

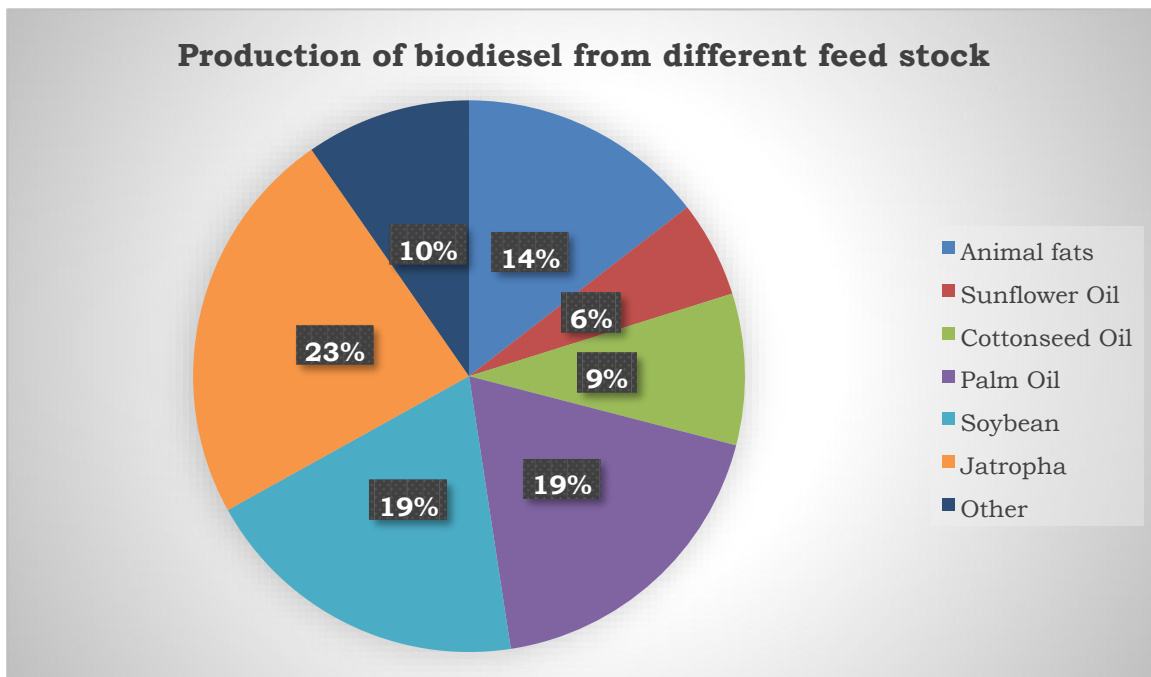
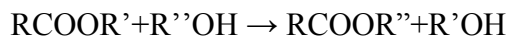


Figure 1: Production of biodiesel from different feed stock

Higher viscosity (20 times more than the diesel) and lower volatility of vegetable oils causes the failure of fuel injector and aggregation of the fuel particles. To reduce the viscosity of former, dilution, micro-emulsification, pyrolysis, and transesterification, processes are used. The transesterification process is used primarily in the quality improvement of the oils, as compared to the other methods. The primary advantage of the transesterification process is to improve the thermo-physical properties of the biodiesel close to the conventional diesel fuel, which make this process more important.

Virtually all biodiesel is engendered in a homogeneous chemical process utilizing base catalyzed transesterification. The transesterification process, also known as alcoholysis, is the replacement of alcohol from an ester by alternative alcohol in a proceduresimilar to hydrolysis. In this process, low temperatures and pressures are the pre-requisitefor the 98% conversion of vegetable oil to biodiesel. In the transesterification process, triglyceride (fat/oil) react with an alcohol in the presence of catalyst and producedthe esters and glycerol. A triglyceride is

composed by glycerin molecules with three long-chain adipose acids [5, 6]. The characteristics of the fat are unyielding by the nature of the adipose acids annexed to the glycerin. The process can be represented by the following reaction:



PREPARATION OF BIODIESEL

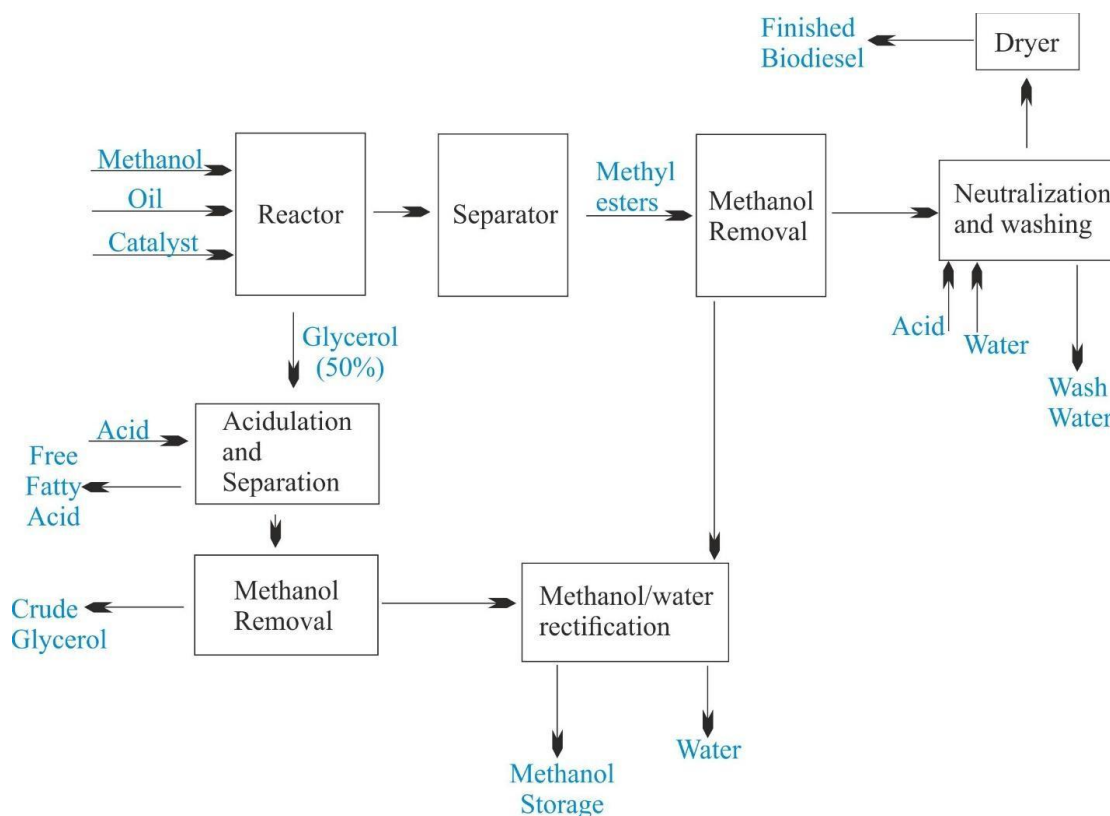


Figure 2: Flowchart of biodiesel production processes

Biodiesel is prepared, as shown in figure 2, by taking a waste cooking oil with cotton seed oil, with 250ml each of the oils is blended in different proportion as 50%WCO+50%CSO, 75% WCO+25% CSO, 25% WCO+75% CSO. On the other hand, sodium hydroxide (which acts as a catalyst) of 2.5 gm is mixed with methanol of 65ml and it is stirred for 10 minutes by using magnetic stirrer and these added solutions is mingled along with the sample taken on previous case. The blended solution is then heated at 55°C at constant temperature for 2 hours which then completes the process of transesterification. The mixture is then putted in separator and it is kept for a 24 hour which results for the separation of two layers where Biodiesel is formed at the top layer along with Glycerol at the bottom layer. Glycerol is extracted from the mixture and Biodiesel is further processed by washing 5 to 6 times to remove the impurities in the sample. Henceforth a pure Biodiesel is obtained.

Most of the biodiesel are made by using transesterification process. In this process, it is necessary to use the accurate amount of the methanol and catalyst to get the proper configuration of the prepared biodiesel. In the following section, the amount of methanol and catalyst is calculated for the present study.

$$\text{Volume of Methanol} = \frac{\text{Density of oil} \times \text{volume of oil} \times \text{molecular weight of methanol} \times 6}{\text{molecular weight of oil} \times \text{density of methanol}}$$

$$\text{Molar weight} = \frac{168300}{\text{Saponification Value}^2 - \text{Acid Aalue}}$$

$$\text{Weight of catalyst} = 0.01 \times \text{Density} \times \text{Volume of oil}$$

About 67.33 ml or about 24% of total volume of oil methanol is required to be complete the transesterification process. The molar weight of prepared biodiesel was found about the 820.69 g/mol. The weight of the used catalyst was calculated about the 2.275 gm. NaOH is required to be complete the transesterification process. Or practically we can also say that 1% of total volume of oil we can also use this figure. But this value is showing approx.



Figure 3: Sample of the prepared biodiesel

Using these parameters have been prepared 3 samples and according to the molecular weight of the samples the catalyst and methanol has been added.

1. 25% Cotton Seed Oil + 75% Waste Cooking Oil
2. 50% Cotton Seed Oil + 50% Waste Cooking Oil
3. 75% Cotton Seed Oil + 25% Waste Cooking Oil

However, final quantity of methanol and catalyst for to complete transesterification are varied up to $\pm 5\%$ only.

CHARACTERIZATION OF BIODIESEL

After the preparation of Biodiesel, it is tested at Sardar Swaran Singh - National Institute of Renewable Energy, Kapurthala, Punjab. The equipment used for testing Biodiesel are Falling

Ball Viscometer Calibration Standard, Hydrometer and Jar Digital Hydrometer. Different properties are listed in the table 1 for the prepared biodiesels.

Table 1: Properties of different blends of prepared biodiesels

S. No.	Biodiesel	Properties	Results	ASTMStandards
1	50%WCO+50%CSO	Density (kg/m ³)	866.99	860-900
		Viscosity (mm ² /s)	5.9	1.9-6
		Specific Gravity	0.8737	
		API Density (g/cm ³)	884.36	
		Cetane Number	56.8	>47
		Carbon Residue	0.345	0.5 (max.)
		Acid Value	1.18	0.5 (max.)
		Flash Point (°C)	152.9	93 (min.)
		Calorific Value (kJ/kg)	39778	
2	25%WCO+75%CSO	Density (kg/m ³)	867.88	860-900
		Viscosity (mm ² /s)	6.4	1.9-6
		Specific Gravity	0.87466	
		API Density (g/cm ³)	885.25	
		Cetane Number	58	>47
		Carbon Residue	0.269	0.5 (max.)
		Acid Value	0.58	0.5 (max.)
		Flash Point (°C)	178.5	93 (min.)
		Calorific Value (kJ/kg)	39528	
3	75%WCO+25%CSO	Density (kg/m ³)	866.4	860-900
		Viscosity (mm ² /s)	5.5	1.9-6
		Specific Gravity	0.87324	
		API Density (g/cm ³)	883.91	
		Cetane Number	56	>47
		Carbon Residue	0.326	0.5 (max.)
		Acid Value	1.23	0.5 (max.)
		Flash Point (°C)	139.5	93 (min.)
		Calorific Value (kJ/kg)	40028	

RESULTS & DISCUSSION

The preparation and characterization of bio-diesel has been conducted in the present study and discussed in the present section. It was very important to analyze the properties of prepared hybrid bio-diesel with respect to the WCO and CSO, individually for various properties such as density, flash point, viscosity, acid value, specific gravity, cetane index and calorific valve of the biodiesel.

From figure 4, it is depicted that CSO has the most density and the least is the combination of 75% WCO+25% CSO. The density of diesel increases in winter weather making the diesel to become thicker like in the form of a gel. Because of higher density, only CSO and WCO cannot be used as a pure fuel. By blending the WCO and CSO in different concentrations, the resulting

fuel is having lower density than the individual, which improves the flow of blends into the fuel system, hence performance of engine.

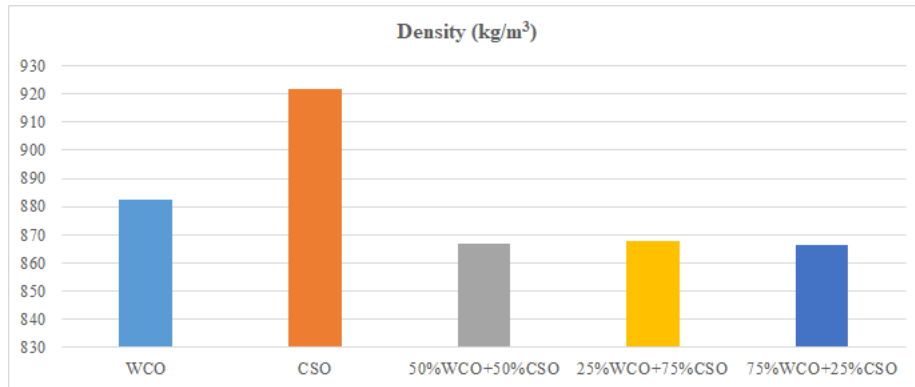


Figure 4: Comparison of density of various samples of bio-diesels.

In the present study, specific gravity of WCO, CSO and different blends were also measured and it was found that WCO has the higher specific gravity, compared to other samples and the least was found for the combination of 75%WCO+25%CSO, as shown in the figure 5. Specific gravity is nothing, but a representation of variation in the density with respect to the water.

The contrary trends were observed for the viscosity of individuals and blends of WCO and CSO. As shown in figure 6, the combination of 75% WCO + 25% CSO given the maximum viscosity among all and the least was found for WCO. The problem of atomization occurred for the blends having higher viscosity, which further can damage the fuel injector. Higher density of fuel also leads to the high work done in the fuel injector to pump the fuel in to cylinder during operation. Due to these unwanted phenomena, the combustion occurs in the cylinder is incomplete and given the poor performance of engine. A higher concentration of CSO leads to higher viscosity, thus the blend should have lower concentration of CSO and higher concentration of WCO to use as a fuel.

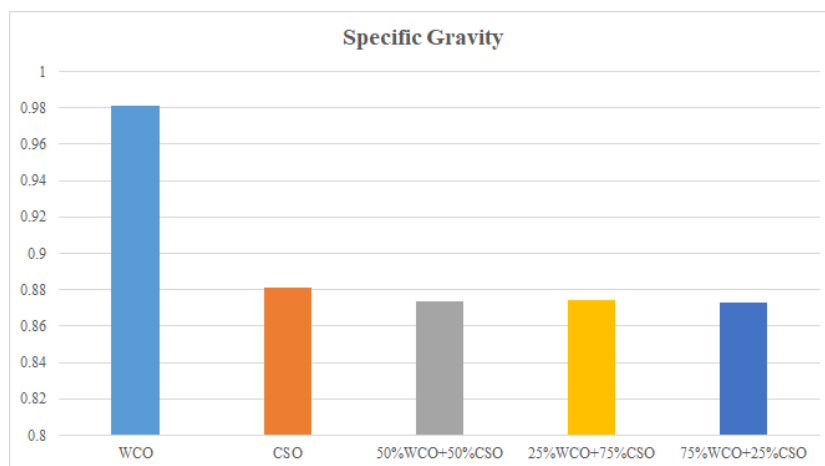


Figure 5: Comparison of specific gravity of various samples of bio-diesels

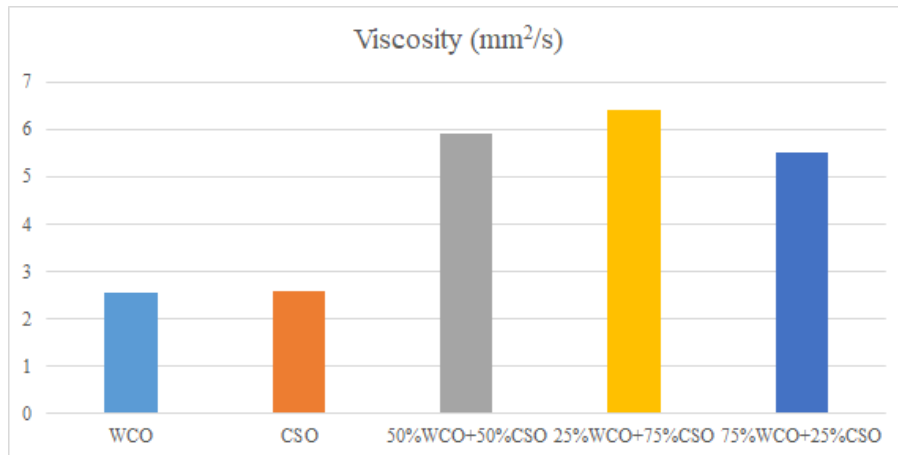


Figure 6: Comparison of viscosity of various samples of bio-diesels.

The cetane number or index was measured for all the fuel samples. From figure 7, it is observed that the blend of 75%CSO+25%WCO was of highestcetane index and the minimum was found for WCO. Increases in cetane number result in early auto-ignition and also reduces ignition delay and decreases in cetane number resultsin the delay in auto-ignition.

The calorific value is an indication of energy available in the fuel. From figure 8, it is depicted that maximum calorific value was observed for the WCO, while the minimum was for the CSO. If calorific value increases, large quantity of heat released during the combustion and more work occurs at the flywheel, increases the thermal efficiency of cycle.

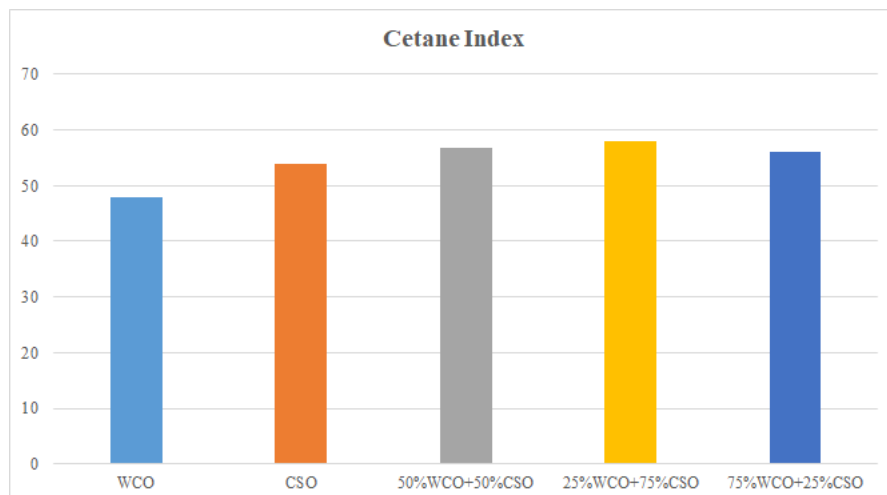


Figure 7: Cetane Index of various samples of bio-diesels

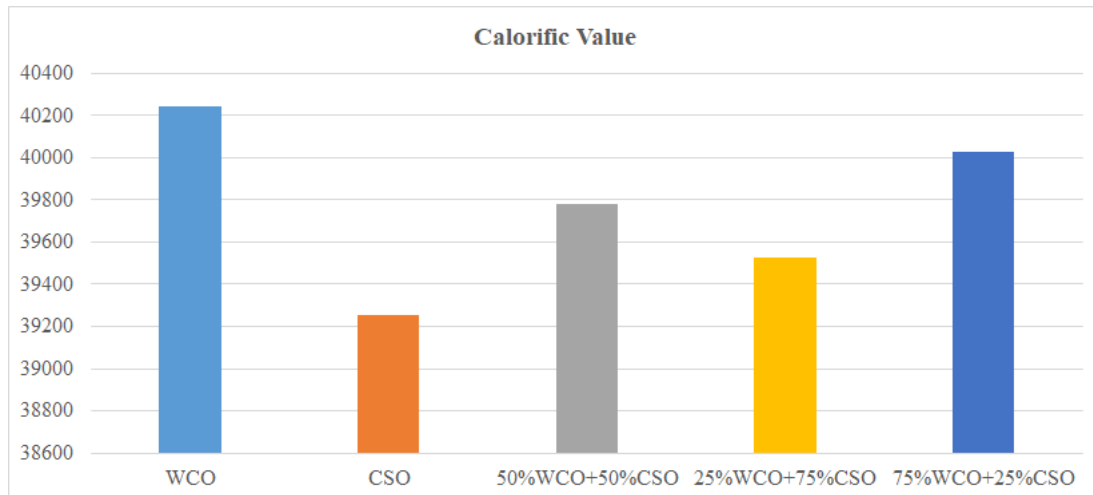


Figure 8: Calorific Value of various samples of bio-diesels

Other properties such as flash point, acid value, etc., also affect the performance of engine. Maximum flash point temperature was observed for the CSO, while minimum was for WCO. For the proper combustion of the fuel in the cylinder, lower value of flash point is required, while the higher flash point prevent the preignition of the fuel which causes due to heat available from the previous cycle in the combustion chamber. Similarly, the acid value of fuel affects the yield strength of the engine, which increases with the reduction in the acid value. The WCO has the higher acid value as compared to the other sample, which means the output of WCO gives less yield strength.

CONCLUSION

Cotton seed oil (CSO) and Waste cooking oil (WCO) bio-diesel is used for the production of Bio-diesel by means of transesterification and blended with second generation Bio-fuel. We have measured the properties like Density, Viscosity, Specific Gravity, Acid Value, Flash Point, Cetane Number and Calorific Value. It was found in the present study that density is higher in pure Cotton seed oil and lower in blended 75% WCO + 25% CSO while viscosity is higher 75% CSO + 25% WCO and lower in pure Waste cooking oil. Somehow Cetane Index is higher in 75% CSO + 25% WCO and lower in Waste cooking oil and also Acid value is higher in Waste cooking oil and to reduce Acid value it is blended with Cotton seed oil to increase its yield strength. Flash point is higher in Cotton seed oil and lower in 75% WCO + 25% CSO, Calorific value is higher in 75% WCO + 25% CSO. From these parameters it is depicted that 75% WCO + 25% CSO is overall the most efficient fuel but the engine performance test is not conducted in the present study.

References

1. Carlos Daniel Mandolesi de Araújo, Claudia Cristina de Andrade, Erika de Souza e Silva, Francisco Antonio Dupas, Biodiesel production from used cooking oil: A review, *Renewable and Sustainable Energy Reviews*, Volume 27, 2013, pp. 445-452. <https://doi.org/10.1016/j.rser.2013.06.014>.
2. Masoumeh Hajjari, Meisam Tabatabaei, MortazaAghbashlo, Hossein Ghanavati, A review on the prospects of sustainable biodiesel production: A global scenario with an emphasis on waste-oil biodiesel utilization, *Renewable and Sustainable Energy Reviews*, Volume 72, 2017, pp. 445-464. <https://doi.org/10.1016/j.rser.2017.01.034>.
3. Aldara da Silva César, Dayana Elizabeth Werderits, Gabriela Leal de Oliveira Saraiva, Ricardo César da Silva Guabiroba, The potential of waste cooking oil as supply for the Brazilian biodiesel chain, *Renewable and Sustainable Energy Reviews*, Volume 72, 2017, pp. 246-253. <https://doi.org/10.1016/j.rser.2016.11.240>.
4. Venkata Mohan S., Chiranjeevi P., Shikha Dahiya, Naresh Kumar A., Waste derived bioeconomy in India: A perspective, *New Biotechnology*, Volume 40, Part A, 2018, pp. 60-69. <https://doi.org/10.1016/j.nbt.2017.06.006>.
5. I.M. Ogbu ,V.I.E. Ajiwe, Biodiesel Production via Esterification of Free Fatty Acids from Cucurbita pepo L. Seed Oil: Kinetic Studies, *International Journal of Science and Technology* Volume 2 No. 8, 2013, pp. 616-621.
6. Anvita Sharma, Pravin Kodgire, Surendra Singh Kachhwaha, Biodiesel production from waste cotton-seed cooking oil using microwave-assisted transesterification: Optimization and kinetic modeling, *Renewable and Sustainable Energy Reviews*, Volume 116, 2019, 109394. <https://doi.org/10.1016/j.rser.2019.109394>.