Biodiesel Production by Non-edible Cascabela Ovata Seeds Through Solvent Methods

M. S. Abishek, Sabindra Kachhap, and Pukhrambam Sunilkhumar Singh

1 Introduction

Renewable energy is a must in the coming future, because of endangering fossil fuel sources. Some sources of renewable energy are 1. hydroelectricity: It uses water motion to generate electricity. The most common method of power hydroelectricity is by processing and controlling the flow of water through a dam. 2. Solar: Solar energy is the light and heat of the sun that is harnessed using a range of technologies such as solar heating, solar thermal energy, and solar architecture. 3. Wind power: It is produced by air flowing through a wind turbine and hence converting the mechanical motion of the turbine to electric energy. 4. Biofuel: Any fuel that is derived from biomass, i.e., plants or algae materials or animal waste utilized hydroxide as a catalyst. The oil of Silybum Marianum is transesterification with methanol to produce biodiesel. They used catalyst as ionic, but they exchange between KF (potassium fluoride) and H_2SO_4 attapulgite by dihydroxylation of the attapulgite at 130 °C for 3 h and subsequent activation of KF at atmospheric temperature and pressure which was followed by calculation at 400 °C for 5 h. The catalyst was 12 wt.% in a 5-h reaction with an ideal temperature of 65 °C. Under these conditions, the best yield was 93.3% [1]. Even though ethanol has a high-water content of 15 wt.%, a high-fatty acid (HFA) conversion more than 90% is produced by optimizing the appropriate reaction time in both systems. It was also concluded that catalytic activity was maintained over time [2]. The biodiesel obtained meets the American Society for Testing and Materials (ASTM) D6751 standard and can be used to prevent food-use fuel competition, making it a suitable alternative to petrol-derived diesel [3]. For the homogeneous reaction, the reaction temperature is 150 and 180 °C, and the ratio of oil to methanol is 1:6 mol/mol with NaOH of 1.0 wt.% as a catalyst. For the heterogeneous reaction, the reaction temperature is 150 °C and 180 °C, and the ratio of oil to methanol is

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1:8 and 1:10, respectively. He used of catalyst amount are 5% and 4 wt.% [4]. The primary oxidation reaction takes place between 100 and 320 °C. Castor pyrolytic acid is likewise discovered to be multi-component, with a high viscosity, a wide boiling range, and low water content. If the ignition temperature was 328 °C, the burnout temperature was 513 °C, and the index of combustion characteristic was 1.991 [5]. The efficient and effective catalyst chosen for the process was KOH. The maximum optimum conditions of biodiesel yield obtained at 91.76% were 0.32% of methanol and KOH 1.5% of catalyst at the temperature of 60 °C during 90 min reaction time. Along with the results predicted by Response Surface Methodology, 88.7% of biodiesel is obtained in the validation experiments fitting 96.6% of the result [6]. During the research, the temperature ranged from 23.5 to 28 °C, with a humidity of 65%. Light duty diesel (LDD) cars have higher CXHY and CO levels than the standard permitted norms, with average values of 430 and 465.4 ppm, respectively, whereas NOx has had an overall average of 99.2 ppm [7]. The results revealed that a biodiesel mixture using 20% apricot oil in diesel performed better and had lower emissions than other different percentages [8]. When compared to diesel fuel, the B20 fuel blend improves BTE by 4.7%, increases CO_2 emissions by 2.56%, and reduces SFC by 7.92%. When compared to diesel fuel, the biodiesel blend (B20) has the biggest reduction in NO_X by 14.9% and particle by 4.22%; however, smoke emission somewhat increases with an increase in fish oil in the blends [9]. Catalysts are important in the transesterification process. Because of their renewability and ease of separation, heterogeneous catalysts have gained popularity in recent years. The utilization of renewable resources to create catalysts has improved the usage of heterogeneous catalysts [10].

1.1 Selected Raw Materials

Cascabela Ovata is a flowering plant. In Manipur, we are called as Utong-Lei, and in Hindi, we are called Pile Kaner. It can be grown up to 12 ft, and its flower is 2–5 mm in size of dia. The color of this flower is yellow, and it is bloom in the summer season. This fruit is dark red–black color, and its size is 4–7 mm dia. It is mainly found in various states of India even the northeast state of Manipur also. It grows in drought tolerance to the high temperature. It is also mainly planted in the valley areas as garden plans (Figs. 1 and 2).

Fig. 1 Cascabela Ovata (Utong-Lei)

Fig. 2 Cascabela Ovata

2 Experimental and Methodology

The experiment was done to extract oil from the raw seed for transesterification process so that the biodiesel and glycerol can be separated. The oil characterization was done to find the properties of oil extracted.

Cascabela Ovata is known as "Utong-Lei" in the local name. It is found almost in all parts of Manipur as a garden plant. The fruits have to be used for oil extraction and accumulated from the local surrounding of Manipur. The collected seeds are accurately weight and noted down. The oil containing seeds extracted from its fruits by using a special mechanism. It is a soft fleshy nut. The size of oil containing seeds is measured. The removed seeds are checked for weight using Electronic Compact Scale. This is done for knowing how much oil we can extract from a known amount of seeds. Ceramic mortar and pestle are used to crush down the Cascabela Ovata seeds fibers into fine particles. It gets a better yield and also time consumed for the extraction. Then oil extraction is done using Soxhlet Apparatus using N-hexane.

2.1 Oil Preparation

See Figs. 3, 4, 5, 6, 7 and 8.

2.2 Oil Characterization

To determine free fatty acid (FFA) content in the oil. If the value of FFA is too high, then the catalyst reaction will be from soap which can prohibit the yield of methyl ester for the present study. The oil value was found 1.46 mg NaOH which is the alkaline limit and is transesterification. Transesterification is done using methanol and NaOH as a catalyst (Figs. 9, 10 and 11).

Fig. 3 Weight of the fruits

Fig. 4 Remove fibers from the fruits

Fig. 5 Weight of the oil-content seeds

Fig. 6 Crushing seeds fibers into fine powder

Fig. 7 Extraction of oil

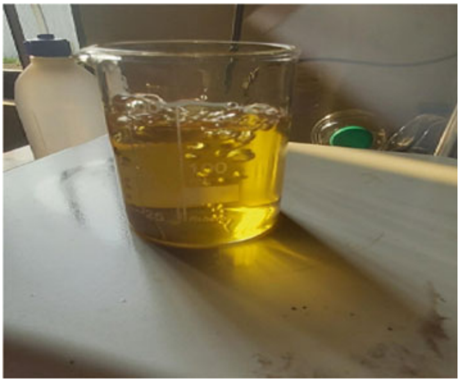

Fig. 8 Removal of excess hexane using hot plate

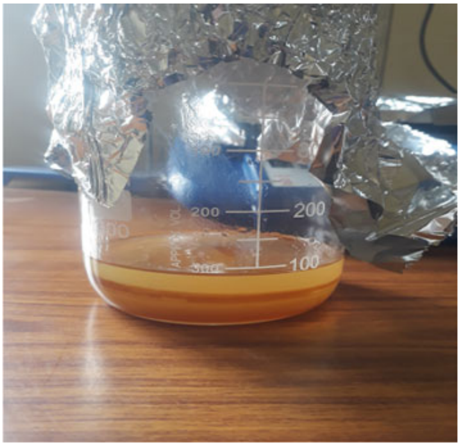

Fig. 9 Separation of glycerol and methyl ester after transesterification

Fig. 10 Methyl ester

3 Results and Discussion

3.1 Weight Percentage of Oil

We consumed a total weight of 375 gm of oil containing seeds, and from that, we extracted 79 gm of oil with that it makes an oil yield percentage of about 68.8%. Comparing yield % between the present solvent study and previous literature on hydraulic [11] and electric [12] press methods as shown in Fig. 12:

$$\text{Oil yield} = \frac{\text{weight of oil produced}}{\text{weight of sample used}} \times 100 \tag{1}$$

Fig. 11 Glycerol

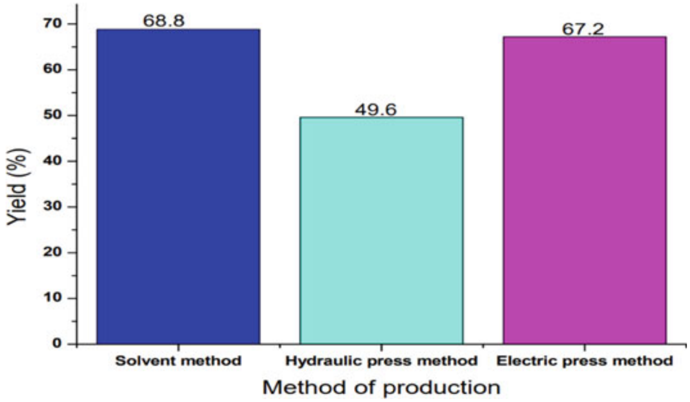

Fig. 12 Yield percentage of oil in different methods

3.2 Specific Gravity

Using the below mention formula, the specific gravity of oil is found to be 0.887 kg/m^3 at 20 °C. Comparing specific gravity in the present solvent study and previous literature on hydraulic and electric [12] press methods as shown in Fig. 13:

$$\text{Specific Gravity} = \frac{\text{Oilfilledwt.} - \text{Emptywt.}}{\text{Distilwaterfilledwt.} - \text{Emptywt.}} \tag{2}$$

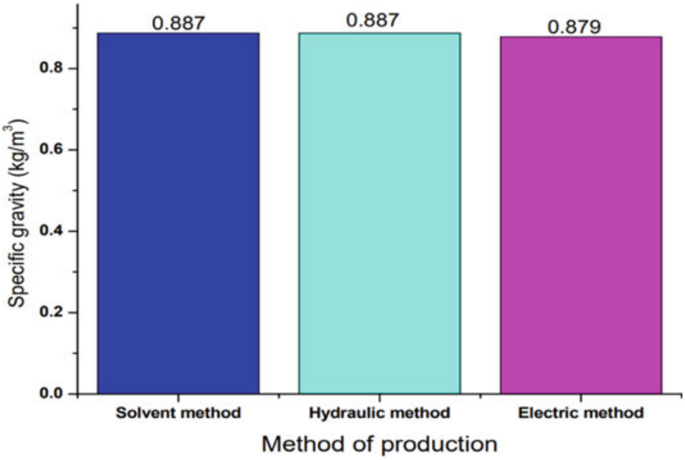

Fig. 13 Specific gravity of oil in different methods

3.3 Kinematic Viscosity

By using the below formula, the kinematic viscosity of the oil is found to be 5.78 mm^2/s at 40 °C and also compared in the present study and previous literature on hydraulic and electric press methods as shown in Fig. 14.

$$\text{Kinematic viscosity} = (\text{Time} \times \text{Tube constant})\ \text{mm}^2/\text{s} \quad (3)$$

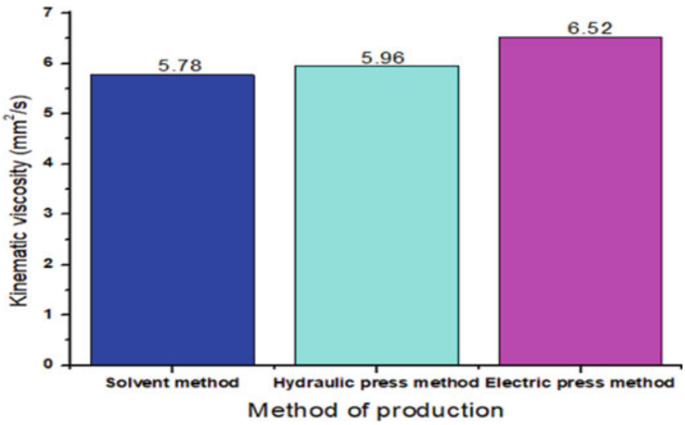

Fig. 14 Kinematic viscosity of different methods of producing oil

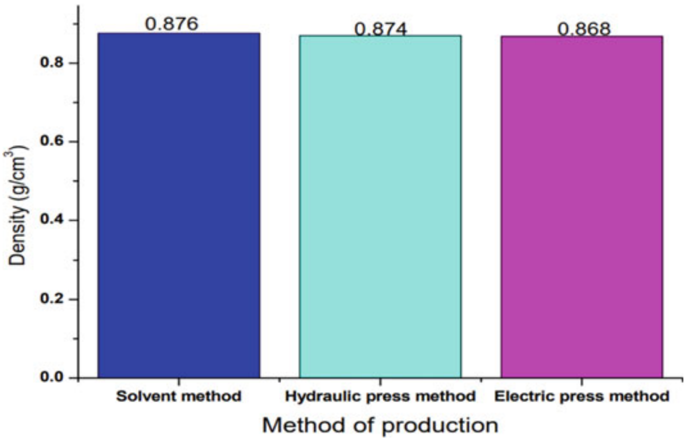

Fig. 15 Density of the oil using different methods

3.4 Density of Oil

Using the below-mentioned formula, we found the density of the oil as 0.876 g/cm^3. Comparing density between the present solvent study and previous literature on hydraulic [11] and electric [12] press method as shown in Fig. 15:

$$\text{Density of oil} = \frac{\text{Mass of oil}}{\text{Volume of oil}} \tag{4}$$

3.5 Flash Point

Cleveland Open cup flashpoint test was used to measure the flashpoint. It is the temperature at which the fuels ignite when exposed to flame. For biodiesel, the average flashpoint is 150 °C. According to the present study, the value of the flashpoint is 96 °C. Comparison of flashpoints in the present solvent study and previous literature on hydraulic [11] and electric [12] press method are shown in Figs. 16, 17 and 18.

3.6 Free Fatty Acid

FFA content is obtained by using the formula given by the equation.

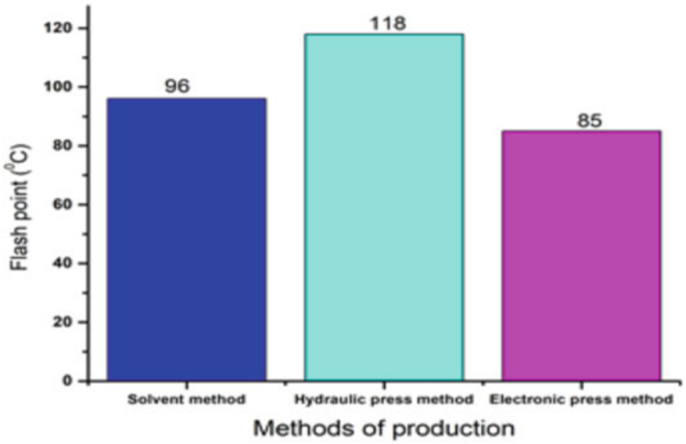

Fig. 16 Flashpoint of different methods of producing oil

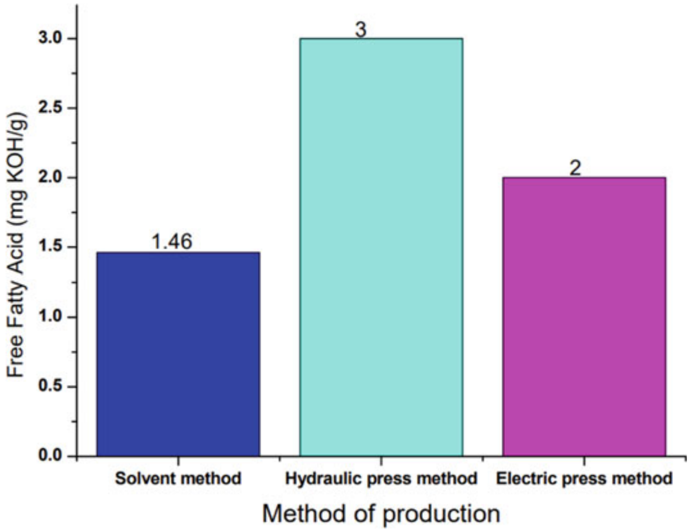

Fig. 17 FFA using different methods of producing oil

$$\text{FFA Content} = \frac{28.2 \times (\text{normality of NaOH xtitration value})}{\text{weight of oil(in gm)}} \quad (5)$$

$$\text{FFA Content} = \frac{28.2 \times (0.1 \times 5.2)}{10} \quad (6)$$

$$\text{FFA Content} = 1.46\% \quad (7)$$

3.7 Fourier Transform Infrared Spectroscopy (FTIR)

FTIR let us know which group the testing sample belongs to. Here is this study by analyzing the graph. We can check for ester groups whether they are strongly stretched or not. In this study, from Figs. 18 and 19, the oil characteristic peaks are found in the range of 3000.95–3008.05 cm^{-1} due to O–H stretching vibration and at 2913.16–2999.26 cm^{-1} due to alkenes C–H stretching vibration. Peaks of C=O stretching vibration of triglyceride ester appear at 1738.65–1743.72 cm^{-1} for the atomic compound of C–H bending at 1451.18–1452.34 cm^{-1}. Also, peaks at 1152.26–1149.15 cm^{-1} are due to C–O–C stretching vibration of esters and that of 729.38–728.71 cm^{-1} due to methylene rocking vibrations are also observed.

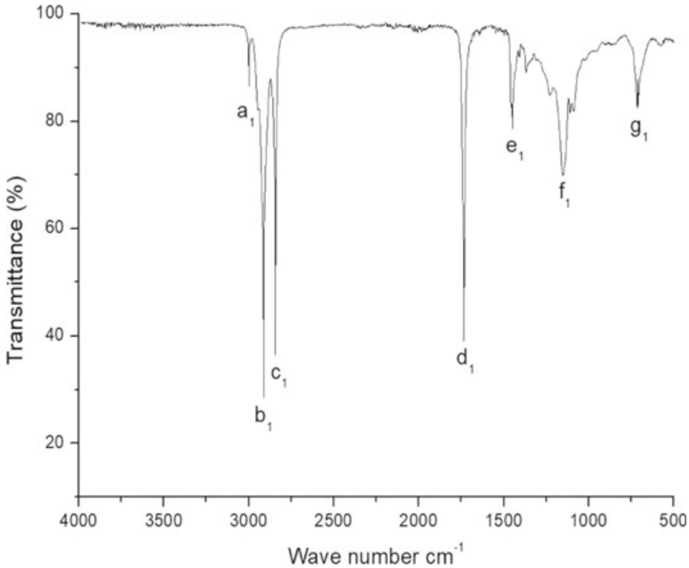

Fig. 18 FTIR test of CO obtained through the solvent

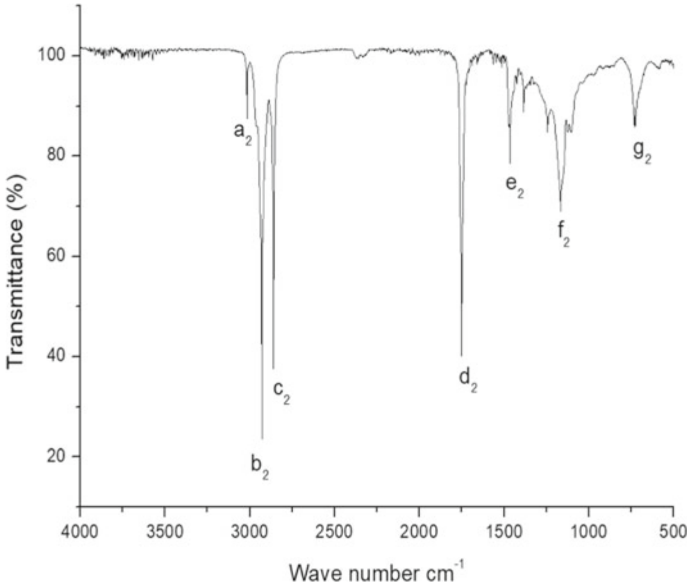

Fig. 19 FTIR tests after transesterification

4 Conclusion

The extraction of oil from Cascabela Ovate seeds is performed using the Soxhlet apparatus. After extraction and carrying out certain tests, it is found that the solvent method yields more than the hydraulic press and electric press methods.

- The following observation is made based on the FTIR test showing a stretching at 1743.65 cm^{-1} indicating the strong presence of C=0.
- The extracted oil yields 68.8%, which has specific gravity and density of 0.88 kg/ m^3 and 0.876 g/cm^3, respectively.
- The amount of fatty acid (FFA) is 1.46% along with kinematic viscosity of 5.78 cSt.
- The extracted oil has a fire point of 96 °C which shows that feedstock used has the potential to be a biofuel.
- As we know, biofuel is a much cleaner and eco-friendly fuel as compared with fossil fuel. Also, by using biofuel, we can reduce environmental pollution, thus giving us a cleaner and safer environment.

4.1 Scope for Further Research

For future works, Cascabela Ovate can be extracted using the expeller press method, and it can find the characteristic of Gas Chromatography Mass Spectrometer (GCMS), Scanning Electron Microscopy (SEM) and Engine Performance of the oil.

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