**The scale** **Journal Website:** https://thescalejournal.com.ng/
**An Interdisciplinary Journal of**
**The ACADEMIC STAFF UNION OF POLYTECHNICS - ZONE D**
**ISSN: 2992-3727 Published 30th November, 2025**

# PRODUCTION OF BIODIESEL FROM CASTOR SEED (*RICIMUS COMMUNIS*) OIL USING TRANSESTERIFICATION PROCESS

**Ibiam J. A.*[1], Okoro O. I.[1], Oji C. O.[1] & Nwali U. I.[1]**
**Department of Science Laboratory Technology, Akanu Ibiam Federal Polytechnic, Unwana**
*Email: amaibiam2002@gmail.com, 08063803459

## ABSTRACT
Biodiesel derived non-edible oils through Trans esterification is recommended for use as a substitute for petroleum-based diesel and could help reduce global warming gas emissions. The study investigated the physico-chemical characteristics of biodiesel from castor seed (*Ricimus communis*) oil using transesterification process in view to evaluate the potentials of castor seed oil in procuring biodiesel. Biodiesel was produced using NaOH transesterification process. The physical properties of the oil and biodiesel produced were analyzed using standard methods. The result obtained include flash point 160℃, pour point 275℃, fire point 215℃, specific gravity 0.855g/cm$^3$, moisture 3.5%, acid value 26.36mg/KOH, free fatty acid 13.18mg/KOH, oil yield 42%, percentage biodiesel yields 71.8%. The result of the study shows that castor seed have a great potential in biodiesel production and since it is non-edible, It is more economical. The biodiesel produced in the study from their physicochemical properties is of good quality and grade as most parameters fall within the recommended limits of ASTM.
**Keywords:** Biodiesel, Oil, Castor seed, Transesterification, Parameters

## Introduction
In recent time, fossil fuel depletion and the increase in atmospheric carbon dioxide concentration are two of the main reasons to promote sustainable alternatives for petroleum products (Sanchez *et al*, 2019). One of the environmental threats faced by planet earth is global warming, owing to the rise in atmospheric greenhouse gases (GHG) based on human activities since the beginning of the industrial revolution. In the quest for sustainable power sources, including a non-toxic, biodegradable, agrarian source called Biofuels (Obayomi *et al*. 2020) were developed and exploited. Biofuels can be gotten directly from power crops or indirectly obtained from agrarian, industrial, Commercial, or domestic wastes. Generally, renewable biofuels require contemporary carbon fixation, as in crops or microalgae by means of photosynthesis, while others are produced using or transforming biomass (referring to previously existing organisms, mostly plant or materials derived from plants (Chai *et al*, 2014). The three distinct methods of transforming biomass into energy containing substances are chemical conversion. Biochemical conversion and heat conversion (Goyal *et al*, 2012). Biofuels can be solid which may include charcoal, fuel wood and wood pellets; gaseous (biogas); or liquid including ethanol, biodiesel and pyrolysis oils. Biodiesel is an equivalent diesel fuel composed of alkyl monoesters of vegetable and animal lipids and as a fuel; it is biodegradable and non-toxic (Rattanaphra *et al*. 2011).
Biodiesel is considered as a real alternative to diesel because of its renewable character and its use in any compression-ignition engine (Balat & Balat, 2010). The most commonly used route to obtain biodiesel is through transesterification of vegetable oils (or other sources such as animal fats) with methanol as an alcohol and NaOH, KOH, $CH_3ONa$, or $CH_3OK$ as catalysts (Balat & Balat, 2010; Santori *et al*, 2012; Leung *et al*, 2010). Due to its fuel properties and compatibility, biodiesel is gaining global consideration. For instance, it has preferred possibilities over petro

diesel, inexhaustible, greater biodegradability than petroleum derivatives, non-toxic. Great lubricity, and essentially sulphur-free and aromatic Marcuetti *et al*, 2012). Biodiesel can possible decrease the level of pollutants and likely cancer-causing agents. It is an environmentally amiable fuel, which can be utilized in any diesel engine devoid of the need to redesign the present technology (Kumar *et al*, 2015). It does not contribute to the development of atmospheric carbon dioxide levels and thus to the greenhouse influence. Despite greater $NO_X$ outflows, biodiesel burning emissions contained reduced CO, $CO_2$, HC and smoke (Dhawane *et al*, 2010). Feed stocks for biodiesel consist of animal fats, vegetable oils. Palm oil, mustard, soy, rapeseed, mahua, jatropha, flax, sunflower, field pennycress, hemp, algae, and *Pngamia pinnnata*. The major feedstock used for the manufacture of biodiesels is vegetable oils. Among them is castor oil that has two fascinating concepts as raw material for biodiesel; on the one side, it does not achieve parity with edible oils; on the other side, does not involve increased input (Canoira *et al*. 2010).

Castor plant (*Ricimus communis* L) is a plant widely distributed throughout the tropical. Subtropical, and warmer temperate regions (Azizzadeh *et al*, 2019). The oil content of castor seed varieties ranges from 45 to 55%, though the actual yield depends on the oil extraction method. Castor oil is non-edible because of the presence of a toxic protein (Pate *et al*, 2019). The fatty acid composition of castor soil reveals that it contains a significant amount of ricinoleic acid (80-90%) (Dias *et al*, 2013), a small amount of linoleic acid (4.5%), oleic acid (3.50%), palmitic acid (1.50%), stearic acid (1.50%), and linoleic acid (0.10) (Dias *et al*. 2013; Keera *et al*, 2018).

Non-edible vegetable oils such as castor oil is considered and appropriate raw material for biodiesel production because it is not used in human diet, its plants can grow in agronomically poor soils. And its oil yield is higher than in the case of other energy crops (Sanchez *et al*, 2019). The main component of this oil is the triglyceride formed of the unsaturated hydroxyl-fatty acid, ricinoleic acid [(9Z, 12R)-12-hydroxy-9-octadecenoic acid]. This compound is the main cause of the high viscosity and polarity of castor oil biodiesel show good properties when mixed with conventional diesel or other less viscous biodiesels (Hurtado *et al*, 2019), and can also be used in mixtures as oil (Estewez *et al*, 2019). In addition, castor oil shows high solubility in alcohols, which favours transesterification (Sanchez *et al,* 2015).

Transesterification is a reversible reaction. When enough catalyst is present in the reaction medium, chemical equilibrium is reached. Methanol is usually added in higher ratios than the stoichiometric ratio (3:1) in order to shift the equilibrium position of the reaction towards the product side. However, this fact strongly increases the final cost of the process due to the fact that methanol expensed are higher. Therefore. The optimization of the process is vital to reduce environmental impacts and costs (Martinez-Guerra *et al*, 2017).

The study serves as a baseline data in the extraction of oil from castor seed (*Ricimus communis*) and the optimum biodiesel production using transesterification-based techniques. The study will enlighten the public on the economic importance of castor seed (*Ricimus communis*) oil and also enhance the utilization of plants seeds. The study will also encourage the Nigeria government to spawn n to the production of biodiesel in order to alleviate dependency on fossil fuels.

The aim of this study is to produce biodiesel from castor seed (*Ricimus communis*) oil using transesterification process and to evaluate the physiochemical characteristics of the oil.

## Materials and Methods

Fresh castor fruit were collected from a local farm in Agubata Village in Ikwo Local Government Area and were labeled, and transported first to the Biology Laboratory for identification and authentication by a taxonomist before taking to Chemistry Laboratory for processing and analysis.

The fruit were washed under tap running water and was sundried for about 5 days for ease of removal and were cut in half to remove the seeds from the coat.

**Extraction of Oil from Castor Seeds**

After separation from the coat or endocarp, castor seeds were washed using distilled water and sun dried for about 5 to 7 days. The seeds were dried in a furnace at temperature of 120℃ to decrease the moisture contained thereof. The seeds were beaten to split open the cell walls to discharge castor fat using a mortar and pestle. About 60g of the sample was positioned into the thimble and 200 mL of petroleum ether was tipped toward the cylindrical bottom container. Soxhlet apparatus was subjected to a temperature of 75℃ and allowed to run for 2 hours continuous extraction maintaining constant temperature.

**Production of Biodiesel through Transesterification**

About 1 mL of undiluted sulphuric acid was added to 100 mL of castor oil produced in a beaker, and was preheated in a water bath at 60℃ to achieve an esterification reaction. About 1 mL of the acid was added to 30 mL of methanol and then transferred to the beaker containing the castor oil, after which it was shaken on a magnetic stirrer for 1 hour. The resulting blend was moved into a detaching flask and permitted to calm by gravity. The transesterification reaction proceeded in a 500 mL 3- neck circular glacial pack reactor equipped with reflux condenser. Through a regulated magnetic heat stirrer. Castor oil was heated to the specified temperature. In order to produce biodiesel, NaOH were combined with methanol with a precise weight. NaOH was mixed with castor oil immediately the oil attained the intended heat level. The level wherein the reactant mixture attains the intended heat level is described as the reaction starting point (t=0). With the aid of a thermocouple equipped with the digital magnetic heat shaker. Heat was supervised and regulated. Once the recommended reaction duration is reached, the blend was calmed and moved in a detaching funnel, where at the base glycerol was separated out of the biodiesel. For the effective separation for the mixture, settling separation time was 120 minutes. Afterwards, glycerol was separated and biodiesel was progressed for detachment phase. Biodiesel Was cleaned by means of a mild water to eliminate the unreacted dissolved NaOH catalyst. Unreacted methanol from biodiesel was retrieved by applying basic distillation where biodiesel was heated to 90℃ for 45 mins.

$$\textbf{\% Biodiesel Yield} = \frac{\textit{Weight of Biodiesel Produced}}{\textit{Weight of Castor Oil used}} \textbf{ x 100}$$

**Physicochemical Characteristics of Extracted Castor Oil**

The physicochemical properties of the castor oil produced was determined according to standard test methods. These properties include the following:

**Determination of Specific Gravity**

About 50 mL pyrometer container was meticulously cleaned using water, dried with petroleum ether and weighed. The bottle was filled with water and weigh. The bottle was dried, the sample poured into it, weighed and evaluated by the formula

$$\textbf{Specific Gravity} = \frac{\textit{Weight of Oil Sample}}{\textit{Weight of Water}}$$

**Determination of Moisture Content**

The oil sample obtained was measured to get the initial weight and desiccated in a furnace at 80℃ for about 8 hours with the weight decided after every 2 hours. A consistent weight obtained after repeating the process was weighed. The sample was removed from the furnace after every 2 hours,

and then positioned in the desiccator for 30 minutes to become cold. After which, was detached and weighed again. The moisture percentage was calculated as follows:

$$\% \text{ Moisture} = \frac{W_1 \quad ^2}{W_3} \text{ X } 100$$

Where;
*W1 is the initial weight of the sample prior to desiccation (g)*
*W2 is the weight of the sample after desiccation (g)*
*W3 is the weight of sample and the desiccator (g)*

**Determination of Flash Point**
About 50 mL of extracted oil sample was transferred into crucible and the heat of the oil sample is gradually raised. A thermometer was suspended into the sample to monitor the rise in temperature. The temperature at which the sample begins flashing and burning was taken as the flash point.

**Determination of Fire Point**
About 50 mL of oil sample was transferred into crucible while the heat of the oil sample gradually raised. A thermometer was suspended into the sample to monitor the rise in temperature. The temperature at which the sample begins flashing and ignition was taken as the Fire Point.

**Determination of Pour Point**
About 50 Ml of soil sample was positioned within a cold-water bath and permitted to stand until it loses its follow features. The point at which the sample appeared hazy, a thermometer was measured and termed as the Pour Point of the sample.

**Statistical Analysis**
Results were obtained in triplicated determination of the physicochemical properties of oil and biodiesel produced and subjected to analysis of variance using SPSS (Statistical Package for Social Science version 22), presented in table and compared to ASTM Standards.

**Results**
The results of the physicochemical properties of castor seed oil and biodiesel produced compared to ASTM Standards are presented in Table 1.

**Table 1: Physicochemical Properties of Extracted Oil and Biodiesel Produced**

| Parameter | Value | ASTM Standard |
|---|---|---|
| Flash point (℃) | 160.50±0.16 | <130 |
| Pour point (℃) | 275.80±0.25 | -20 |
| Fire point(℃) | 215.10±0.08 | - |
| Specific gravity (d/cm$^3$) | 0.86±0.01 | 0.85 |
| Moisture content (%) | 3.50±0.04 | 0.02 |
| Acid value (mg/KOH) | 26.36±0.07 | 0.50 |
| Free fatty acid (mg/KOH) | 13.18±0.21 | 0.50 |
| Oil yield (%) | 42.40±0.09 | - |
| Biodiesel yield (%) | 71.80±0.08 | - |

## Discussion

The results of the Flash point was 160.50±0.16℃ and it was in conformity to ASTM Standard which was >130℃. Flash point is the lowest temperature at which a fuel can ignite when exposed to a flame. The flash point of biodiesel corresponds to both the percentage amount of hydrocarbon saturated compounds and the residual of alcohol. In terms of safety, the lower the flash point, the higher the cost for the storage system. In this study, the flash points of the obtained biodiesel were within the ASTM Limit of >130℃ and higher than 130℃ minimum point and therefore pose no risk of fire outbreaks in case of accidents. This is an indication that biodiesel produced form the castor seeds will be combustible hence could be used as for internal combustion engines.

The pour point refers to the lowest temperature at which there is movement of the fuel when the container is tipped. As recommended by ASTM, the pour point of biodiesel should fall within the range of -20℃. In the study the pour point determined is 275.80±0.25℃ which implies that the biodiesel produced can move out of the container at high temperature therefore storage should be recommended below the pour point.

The fire point reflects the temperature of explosion or flammability of the biodiesel which in the study is 215.10±0.08℃. This result shows that the biodiesel produced can only be flammable at ta temperature of 215℃ reducing the risk of fire outbreak in combustion engines.

The results of the percentage yields of the extracted castor oil, produced biodiesel and their physicochemical characterization with reference to the ASTM Standards are presented in Table 1 above. From the above results the specific gravity obtained is 0.86 g/cm$^3$. The result of the study is in line with ASTM Standards of 0.86±0.01g/cm$^3$ specific gravity for biodiesel and oils for biodiesel production. Specific gravity of biodiesel depends on the composition of fatty acid (Onyezaka *et al*, 2020). Specific gravity is an important fuel property, because injection systems, pumps and injectors must deliver an amount of fuel precisely adjusted to provide proper combustion. The specific gravity values must be maintained with tolerable limits to allow optimal air-to-fuel rations for complete combustion. High specific gravity biodiesel can lead to incomplete combustion and particulate matter emissions (Onyezaka *et al*, 2020). The result obtained in the study is evident that the biodiesel produced from castor seed oil will have adequate combustion even as they are in the same close margin with ASTM Standards.

The results in Table 1 show the percentage moisture of Castor seed oil to be 3.50±0.04%. The moisture content of castor see oil in the study is higher than ASTM recommended value of 0.02%. The moisture contents of the biodiesel samples made from castor oil reflects the quality of the obtained biodiesel. High moisture content in biodiesel may cause many problems such as water accumulation and microbial growth in fuel handling, storage and transportation equipment (Onyezaka *et al*, 2020). It is often caused by improper treatment after processing or by absorption of atmospheric moisture during storage. In the study, the biodiesel is no doubt containing a significant amount of water which may reduce efficiency.

The acid vale determined in the study is 26.36 mg/KOH. Determination of acid value is an important test to assess the quality of a particular biodiesel. The acid value of a starting material can play an important role on the % Fatty acid methyl ester of the final product (Charoenchaitrakool & Thienmethangkoon, 2011). The reported acid value of 26.36 mg/KOH though greater than the maximum vale set by ASTM (0.50) is an indication that the biodiesel produce would have corrosion problem when used or stored (Ogunwole, 2015).

The study determined a free fatty acid value of 13.18±0.21 mg/KOH which were higher than ASTM Standards of 0.05 m/KOH implying that the biodiesel produced will be exceedingly difficult leading to a low yield of biodiesel.

**ISSN: 2992-3727 Published 30th November, 2025**

## Conclusion

Biodiesel derived from non-edible oils through transesterification is recommended for use as a substitute for petroleum-based diesel and could help reduce global warming and gas emissions. The results of the study show that castor seed have a great potential in biodiesel production, and since it is non-edible, it is more economical. The biodiesel produced in the study from their physicochemical properties are of good quality and grade, as most parameters fall with the recommended limits of ASTM Standards.

## Recommendations

i. Government should explore options to alleviate dependency on fossil fuels as biodiesel is an alternative;
ii. The study recommends advances in biodiesel purification;
iii. There is need to explore the use of waste as alternative sources in biodiesel production rather than food crops in order to reduce/cushion the unavailability of raw materials for biodiesel production.

## References

Al- Esawi, N., Al Qubeissi, M. & Kolodnystska, R. (2019). The impact of biodiesel fuel on ethanol/diesel blends. *Energies*, 12: 1804

Arora, R., Kapoor, V. & Toor, A. P. (2014). Esterification of free fatty acids in waste oil using a carbon based solid acid catalyst. *ICETET*, 4: 196-199

Azizzadeh, S., Hajlari, B., Najafi, N. and Faizollahzadeh, A. S. (2019). Castor Oil, a source for biodiesel production and its impact on the diesel engine performance. *Renewable Energy Focus,* 28: 1-10

Balat, M. & Balat, H. (2019). Progress in biodiesel processing. *Appl. Energy,* 87: 1815-1835

Banana, R. & Youssef, S. (2015). Waste frying oil with high levels of free fatty acids as one of the prominent sources of biodiesel production. *J. Mater. Environ. Sci*., 6(4): 1178-1185

Canoira, L., Garcia, G. J., Alca'ntra, R., Lapuerta, M. & Garcia-Contreras, C. (2010). Fatty acid methyl esters (FAMES) from castor oil: Production process assessment and synergistic effects in its properties, *Renewable Energy*, 35(1): 208-217

Chai, M., Tu, Q. & Lu, M. (2014) Esterification pretreatment of free fatty acid in biodiesel production, from laboratory to industry. *Fuel process Technol*., 125: 106-113

Charoenchaitrakool, M. & Thienmethangkoon, J. (2011). Statistical Optimization for biodiesel production form waste frying oil through two-step catalyzed process. *Fuel Processing Technology*, 92(1): 112-118. DOI:10.1016/j.fuproc.2010.09.012

Dhawane, S. H.M Kumar, T. & Halder, G. (2016). Parametric effects and optimization on synthesis of iron (II) doped carbonaceous catalyst for the production of biodiesel. *Energy Conversion and Management*, 122: 310-320

Dias, M. J., Arau'jo, J. M., Costa, J. F., Alvim-Ferraz M. C. M. & Almeida, M. F. (2013). Biodiesel production from raw castor oil, *Energy*, 53: 58-66

Estevez, R., Aguado-Deblas, L., Posadillo, A., Hurtado, B., Bautista, F. M., Hidalgo, J. M., Luna, C., Calero, J., Romero, A. A. & Luna, D. (2019). Performance and emission quality assessment in a diesel engine of straight castor and sunflower vegetable oils. In diesel/ gasoline /oil triple blends. *Energies*, 12: 2181

Goyal, P., Sharma, M. P. & Jain, S. (2012). Optimization of esterification and transesterification of high FFA *Jatropha curcas* oil using response surface methodology, *j. Petro Sci. Res*., 1: 36-43

Hurtado, B., Posadillo, A., Luna, D., Bautista, F. M., Hidalgo, J. M., Luna, C., Calero, J., Romero, A. A. & Estevez, R. (2019). Synthesis, performance and emission quality assessment of eco-diesel from castor oil in diesel/ biofuel/alcohol triple blends in a diesel engines. *Catalysts*, 9: 40

Keera, S. T., El Sabagh, S. M. & Taman, A. R. (2018). Castor oil biodiesel production and optimization. *Egyptian Journal of Petroleum*, 27(4): 979-984

Kumar, S., Chary, G. H. V. C. & Dastidar, M. G. (2015). Optimization studies on coal-oil agglomeration using Taguchi (L16) experimental design. *Fuel*, 141: 9-16

Leung, D. Y. C., Wu, X. & Leung, M. K. H. A review on biodiesel production using catalyzed transesterification. *Appl. Energy*, 87: 1083-1095

Marchetti, J. M., Pedernera, M. N. & Schbib, N. S. (2012). Production of biodiesel from acid oil using sulphuric acid as catalyst: kinetics study. *Int. K. Low Carbon Technol*., 6: 38-43

Martinez-Guerra, E. & Gnaneswar Gude, V. (2017). Assessment of sustainability indicators for biodiesel production. *Appl. Sci*., 7: 869

Obayomi, K. S., Bello, I. J. O., Ogundipe, T. A. & Olawale, O. (2020). Extraction of castor oil from castor seed for optimization of biodiesel production. IOP Conf. Series: *Earth and Environmental Science,* 445: 12055

Ogunwole, O. A. (2015). Production of Biodiesel from Watermelon Seed Oil (*Citrullus vulgaris*). Mechanical Engineering Department, Federal University of Technology Minna Nigeria. *Leonardo Journal of Sciences*, pp. 63-74

Onyezeka, E. G. Nnaji, J. C., Omotugba, S. K. & Garba, M. H. (2020). Physicochemical properties of biodiesel produced by transesterification of various esterified waste frying oils. *Nigerian Journal of Chemical Research*, 25(4): 44-56

Patel, V. R., Dumancas, G. G. Viswanath, L. C. K., Maples, R. & Subong, B. J. J. (2016). Castor oil: Properties, uses, and optimization of processing parameters in commercial production. *Lipid Insights*, 9(1): 1-12

Rattanaphra, D., Harvey, A. P., Thanapimmetha, A. & Srinophakum, P. (2011). Kinetic of myristic acid esterification with methanol in the presence of triglycerides over sulphated zirconia. *Renew Energy*, 36: 2679-86

Sanchez, N. Sanchez, R. Encinar, J. M., Gonzalez, J. F. & Martinez, G. (2015). Complete analysis of castor oil methanolysis to obtain biodiesel. Fuel, 147: 95-99

Santori, G., Di Nicola, G., Moglie, M. and Polonara, F. (2012). A review analyzing the industrial biodiesel production practice starting from vegetable oil refining. *Appl. Energy*, 92: 109-132