



## Physicochemical Characterization of Biodiesel Produced from *Sesamum indicum* Seeds

\*Tambuwal A.D. and Okoh E.V.C.

Department of Pure and Applied Chemistry, Usmanu Danfodiyo University Sokoto, Nigeria

### ABSTRACT

*Sesamum indicum* is an herbaceous plant which belongs to the family of Pedaliaceae. It is native to India, Sudan, China, Burma and Nigeria. The objective of this study was to assess some parameters and characterized biodiesel from the sesame using ASTM specifications. The result indicated that sesame seeds contained 66.67% oil while the percentage biodiesel produced from the oil was 86.67%. The moisture, density, acid value, free fatty acid, iodine and pH of the extracted sesame oil and biodiesel are 0.03 and 0.02, 0.08 and 0.87, 135.20 and 33.66, 13.52 and 3.36, 44.61 and 32.80 and 5.90 and 5.32 respectively. The viscosity and flash point of the biodiesel is 2.40 and 180 respectively. In conclusion, sesame seed oil has potential application for biodiesel production.

**Keywords:** *Sesamum indicum*, Biodiesel, Sesame, Transesterification

### INTRODUCTION

Biodiesel is reported to be a non-conventional renewable energy source derived from biological sources like vegetable oil, animal fat and waste, cooking oil (Kilic *et al.*, 2013; Antoln *et al.*, 2002). Biodiesel is also reported to be a mixture of alkyl esters and it can be used in conventional compression ignition engines without modification. This alternative fuel has been successfully produced by transesterification of vegetable oils and animal fats using suitable catalysts (Mushrush *et al.*, 2001; Wardle, 2003). The demand for energy is ever increasing at an exponential rate as the population of humans increases in developing countries. This demand is occasioned by the depleting amount of fossil fuel resources with the continuous utilization of fossil fuels being unsustainable and its continuous exploitation leads to environmental degradation and increased emission of greenhouse gases. Hence, the use of alternative sources of energy, such as biofuels, is attracting the interest of researchers (Cheenkachorn and Fungtammasan, 2009). In recent years, biodiesel has gained international attention as a source of alternative fuel due to characteristics like high degradability, low toxicity and emission of carbon (II) oxide, particulate matter and unburned hydrocarbons (Vicente *et al.*, 1998; Al Zuhair, 2007).

*Sesamum indicum* is a herbaceous plant which belong to the family of Pedaliaceae. Sesame seed has one of the highest oil contents of any seed and is considered to be the oldest oilseed crop known to man, highly resistant to drought and has the ability of growing where most crops fail (Koca *et al.*, 2007; Elleuch *et al.*, 2007). The seed colour varies from cream-white to charcoal black but it is mainly black. In Nigeria, the notable colours of sesame seed are white, yellow and black (Fariku *et al.*, 2007). The major world producers and exporters include India, Sudan, China and Burma and Nigeria (El Khier *et al.*, 2008). The fat of sesame is of importance in the food industry due to its flavour and stability, its oil has been found to contain sesamin and sesaminol lignans in its non-glycerol fraction, which are known to play an important role in the oxidative stability and antioxidant activity (Wu, 2007). The main fatty acid composition of the oil is oleic (43%), linoleic (35%), palmitic (11%) and stearic (7%) acids, contributing about 96% of the total fatty acids (Elleuch *et al.*, 2007; Borchani *et al.*, 2010). It also contains some polyunsaturated fatty acids basically Omega 6 fatty acids but lacks Omega 3 fatty acids

Sesame seed is cultivated and produced in

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Address Correspondence to:

[amamadahiru@yahoo.co.uk](mailto:amamadahiru@yahoo.co.uk)

large quantity in Nigeria, especially in the Northern part of the country and is under-utilized in some parts of the country. Therefore, there is a greater need to utilize some for energy purposes. Based on the recent statement that Nigeria envisions an energy transition from crude oil to renewable energy (ECN, 2005). This work aims to obtain sesame oil from locally procured sesame seeds, produced biodiesel from the produced sesame oil and to characterize the produced sesame oil and biodiesel with reference ASTM, 2002 standards.

## METHODOLOGY

### Sample collection

Matured and healthy sesame seeds were purchased from Zuru Central Market, Kebbi State of Nigeria in 2017. They were washed with clean running water to remove earthy impurities, dried and transported to the chemical laboratory of the Sokoto Energy Research Centre in clean polythene bags. The samples were identified and authenticated at the Botany Unit, Department of Biological Science, Usmanu Danfodiyo University, Sokoto where a herbarium specimen was deposited and a voucher number UDUH/ANS/0084 issued. They were powdered with the aid of a clean mortar and pestle before being stored in an air tight glass container until further use.

### Chemicals

Ethanol, n-hexane, phenolphthalein indicator, hydrochloric acid and potassium hydroxide were procured from BDH England while methanol was procured from May and Baker. All chemicals used for the study were all of analytical grade.

### Extraction of oil from the sesame seeds

The procedure described by Kaniz *et al.*, 2012 with slight modification was employed. 120 g of the powdered sample was weighed and extracted exhaustively with 250 ml of n-hexane using a soxhlet extractor for 3 hours at 50°C. During extraction, the n-hexane evaporates, condenses as liquid and mixing with the extracted sesame seed oil in the round bottom flask. The sesame oil was obtained after the careful evaporation of the n-hexane from the round bottom flask into the extraction

chamber. The percentage yield of the extracted oil was determined using the expression:

$$\% \text{ oil yield} = \frac{\text{Mass of Extracted}}{\text{Mass of Powdered Sample}} \times 100 \quad (1)$$

### Biodiesel production via transesterification reaction

The procedure described by Karimet *et al.*, 2014 with slight modification was employed. 30 ml of the produced oil was mixed with 0.3 g of CaO (acting as catalyst) and 6ml of methanol. The mixture was placed in a water bath for 1 hour at 60°C. The washed biodiesel were collected into a beaker and gently heated in an oven at 105°C to evaporate the excess water and methanol from the biodiesel. The resulting solution was transferred into a separation funnel, allowed to stand for 24 hours were distinct layers of biodiesel, glycerine and catalyst was observed. They were then collected into separate containers. The percentage yield of the biodiesel produced is determined using the expression:

$$\% \text{ biodiesel yield} = \frac{\text{Mass of Biodiesel Produced}}{\text{Mass of Oil Used}} \times 100 \quad (2)$$

### Physicochemical characterization of the extracted sesame oil and produced biodiesel

The method described by Ogunwole 2015 was used to determine the acid value and iodine value. The methods described by Knothe 2009, Belewu *et al.*, 2010, and Galadima *et al.*, 2009 with slight modifications was used to determine the free fatty acid content, moisture content, flash point and density respectively. The pH value and the viscosity were determined using the pH meter and rotational viscometer respectively in adherence to the standard operating procedure of the apparatus. The analyses were conducted at the Chemistry laboratory and Sokoto Energy Research Chemical laboratory, Usmanu Danfodiyo University Sokoto, Sokoto State Nigeria

## RESULTS AND DISCUSSIONS

The results of the percentage yields of the extracted sesame oil, produced biodiesel and their physicochemical characterization with reference to the ASTM 2002 standard is represented in Table 1.

Table 1: % yields of the extracted sesame oil, produced biodiesel and their physicochemical characterization

| Parameters   | Sesame oil | Sesame biodiesel | ASTM Standard |
|--|------------|------------------|---------------|
| Percentage yield (%)                                 | 66.67      | 86.67            | -             |
| Moisture content (%)                                 | 0.03       | 0.02             | <0.03         |
| Density at 15 °C (g/cm <sup>3</sup> )                | 0.88       | 0.87             | 0.82-0.90     |
| Acid value (mg KOH/g)                                | 135.20     | 33.66            | 0.50          |
| Kinematic viscosity at 33.5°C (mm <sup>2</sup> /sec) | -          | 2.40             | 1.90-6.0      |
| Free fatty acid (mg/g)                               | 13.52      | 3.36             | 0.50          |
| Iodine value (g I <sub>2</sub> /100g)                | 44.61      | 32.80            | 130           |
| pH value   | 5.90       | 5.32             | -             |
| Flash point (°C)                                     | -          | 180              | >130          |

Legend: (-) = Not applicable

The percentage yield of 66.67% of oil showed that the sesame seeds are moderate oil yielding seed and therefore an economically viable source of oil. The result also shows that the sesame oil yield a higher percentage 86.67% of biodiesel using CaO as catalyst. The density of 0.87 g/cm<sup>3</sup> of the produced biodiesel is within the ASTM specification therefore can be used as an alternative source of fuel (Galadima *et al.*, 2009). The reported acid value of 135.20 mgKOH/g and 33.66 mgKOH/g for sesame oil and biodiesel thou greater than the maximum value set by ASTM is an indication that the biodiesel produced would have corrosion problem when used or stored (Ogunwale, 2015). The iodine value is a parameter to measure the total level of unsaturation in the oil and by extension the biodiesel quality (Belewu *et al.*, 2010). The reported iodine values of the sesame oil and the biodiesel produced from the sesame seeds are within the range of ASTM standard hence laying credence with the quality of the biodiesel produced. The moisture content is the measure of the quantity of water present in the oil and biodiesel sample. The results indicated that the moisture content was found to be within the acceptable range of ASTM standard for sesame biodiesel hence can be stored for a long period of time without damage but that could not be said for the sesame oil since it falls outside the ASTM standard. The result of the moisture content for the sesame oil is in agreement with that reported by Eriola and Tunde (2013) but was in disagreement with that reported for sesame biodiesel. The reported flash point of 180°C for the biodiesel produced from the sesame seeds is within the recommended value of ASTM and in agreement with that reported by

Eriola and Tunde (2013). This is an indication that biodiesel produced from the sesame seeds will be combustible hence could be used as fuel for internal combustion engines. The result of the kinematic viscosity of the produced biodiesel thou is less than that reported by Eriola and Tunde, (2013) but was within the ASTM standard.

### Conclusion

The research revealed that sesame seed has a good potential source for oil and biodiesel production. The physicochemical parameters like density, iodine value, moisture content, viscosity and flash point were all within the ASTM specifications, while the acid value and free fatty acids were both above the permissible limits.

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