International Journal of Agricultural Engineering, Vol. 3 No. 1 (April, 2010) : 125-129

Research Paper :

Study of properties of *Calophyllum inophyllum* L. oil and its biodiesel

A.G. MOHOD, P.P. BHOR, K.N. KADAM, S.H. SENGAR AND Y.P. KHANDETOD

Accepted : *March, 2010*

See end of the article for authors' affiliations

Correspondence to:
A.G. MOHOD
Department of Electrical and Other Energy Sources, College of Agricultural Engineering and Technology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, RATNAGIRI (M.S.) INDIA

ABSTRACT

The methyl ester was prepared from *Calophyllum Inophyllum* L. oil by using base catalyzed transesterification process. Different properties of raw *Calophyllum inophyllum* L. oil and its methyl ester were determined by using the standard procedures. The specific gravity and kinematic viscosity, Gross calorific value, Flash point, Fire point, Acid value, Free fatty acid content and Saponification value for raw Undi oil were 0.908, 5.80 cS, 35.55 MJ/Kg, 248^{0}C, 283 ^{0}C, 0.933 mg KOH/g, 1.2 %, 210, respectively, While for Undi methyl ester were 0.856, 3.58 cS, 39.21 MJ/Kg, 188 ^{0}C, 231 ^{0}C, 0.523 mg KOH/g, 0.66 %, 200.7, respectively.

Key words : Fuel properties, Properties of biodiesel, Undi biodiesel.

The demand for energy consumption in automobiles and agricultural sector in India has been growing along with the economic progress. India was facing problems in regard to the fuel requirement for increased transportation demand and was importing about 70 per cent of its petroleum requirement. The yearly consumption of diesel was about 40 million tones in 2004-2005 forming 40 per cent of the total petroleum product consumption and expected to reach 52.32 million tones by 2006-07 growing at about 5.6 per cent annually. Biodiesel was methyl or ethyl ester of fatty acid made from virgin or used vegetable oils (both edible and non-edible) and animal fats.

The coastal area of Konkan region of Maharashtra lying between 150 37' and 20020' N latitude and 720 7' and 74030' E longitude was endeavored with naturally available non-edible oilseed crop known as *Calophyllum inophyllum* L. The oil content of the its seeds varies from 50-73 %. It is a medium-sized tree, normally up to 25 m tall, occasionally reaching up to 35 m and diameter up to 150 cm. The potential of Undi oil was yet to be exploited as a biodiesel (Joker, 2004). Also a small capacity biodiesel processor must be fabricated for biodiesel production at farm level with locally available material. Hence, the research was conducted to determine the properties of raw Undi (*Calophyllum inophyllum* L.) oil and biodiesel.

METHODOLOGY

Different properties of Undi oil and Undi biodiesel were calculated for comparison with another fuel as follows.

Determination of density:

Density was measured by the standard test procedure of Bureau of Indian Standards (WAS 1448). Density of *Calophyllum inophyllum* oil and its methyl ester were calculated using the following equation :

Density, $d = (m_2 - m_1) / 50$

where, d = density of oil, g/ml

m_2 = Mass of density bottle plus oil, g

m_1 = Mass of density bottle, g

Determination of specific gravity:

The specific gravity is the ratio of the density of substance to a reference density. The most common reference density used in the measurement of specific gravity was water, which corresponds to reference density of 1 g/cc. Specific gravity of raw *Calophyllum inophyllum* L. oil and its methyl ester were calculated as,

Specific gravity = d/n_{ref}

where, n_{ref} = reference density of water, g/ml.

Determination of kinematic viscosity:

Kinematic vacuity was measured as per standard test procedure of Bureau of Indian Standards (WAS 1448). Kinematic viscosity was the resistance to flow of a fluid under gravity. Redwood Viscometer No.1 was used to determine the Kinematic vacuity of raw *Calophyllum*

inophyllum oil and its methyl ester. The time required to flow 50 ml oil having temperature of 38^0 C was measured. The Kinematic vacuity of raw *Calophyllum inophyllum* oil and its methyl ester were calculated as,

Kinematic vacuity of oil, $V_k = 0.26t - 179/t$ for $34 < t < 100$

and **Kinematic vacuity of oil, $V_k = 0.24t - 50/t$ for $t > 100$**

where, V_k = kinematic vacuity of oil, c
t = time of flow, s

Determination of gross calorific value:

Gross calorific value was measured by the standard test procedure of Bureau of Indian Standards (WAS 1448). The calorific value measures the quantity of energy released when a sample of fuel was burnt in a constant volume enclosure. An oxygen Bomb calorimeter was used to find out gross calorific value of raw undi oil and its methyl ester. The gross calorific value of raw undi *Calophyllum inophyllum* oil and its methyl ester were calculated as:

$$L = (W_w + w)(t_2 - t_1) / M_f$$

where, L = Gross calorific value of oil in Kcal/Kg
M_f = Mass of fuel taken in crucible, g
W_w = Mass of water in calorimeter, g
w = Water equivalent of calorimeter, stirrer, thermometer, g
t_1 = Initial temperature of water in calorimeter, ^{0}C
t_2 = Final temperature of water in calorimeter, ^{0}C

Determination of flash point:

Flash point was measured by the standard test procedure of Bureau of Indian Standards (WAS 1448). Flash point was taken as the lowest temperature at which the flame caused the above the sample ignites momentarily. Pensky-Martens Closed cup apparatus were used to measure the flash point of raw *Calophyllum inophyllum* oil and its methyl ester. The temperature was noted at which vapor caused above the oil ignite momentarily.

Determination of fire point:

The fire point is the temperature at which the fuel vapors above an open cup of fuel are flammable, but also contain enough energy to heat the surface of the fuel, vaporizing more fuel and leading to a sustained pool fire. The Pensky Martens Closed cup apparatus were used for measuring the fire point of raw undi *Calophyllum inophyllum* oil and its methyl ester. The temperature was noted at which oil leading to a sustained pool fire.

Determination of acid value:

Acid value is the number of milligram of KOH to neutralize the free acid present in 1 g of oil. Acid value of raw *Calophyllum inophyllum* oil and its methyl ester were calculated as follows (Dara, 1999)

Acid value of oil = (Number of ml of KOH x 5.6) / W_u

where, W_u = Weight of oil taken, g

Determination of free fatty acid (FFA) value:

A 10 g of oil was titrated with aqueous solution of 0.1 N solution of NaOH. The per cent free fatty acid of raw *Calophyllum inophyllum* oil and its methyl ester were calculated as follows (Dara, 1999),

$$FFA = (V_n \times N \times M) / (10 \times W_u)$$

where, V_n = Volume of NaOH used, ml
N = Normality of NaOH
M = Molecular weight of NaOH
W_u = Weight of oil, g.

Determination of saponification value:

Saponification value is the number of milligrams of KOH required to neutralize the free fatty acids resulting from the complete hydrolysis of one gram of oil. Saponification value of raw *Calophyllum inophyllum* oil and its methyl ester were calculated as follows (Dara, 1999),

Saponification value = (X – Y) x 28 / W_u

where, X = Volume of 0.5 N HCL require to titrate the blank experiment flask.
Y = Volume of 0.5 N HCL require to titrate the flask containing the Undi oil.
W_u = Weight of oil, g

RESULTS AND DISCUSSION

The findings obtained from the present investigation have been discussed in the following sub heads:

Different properties of oil and oil methyl ester:

Density:

The density of Undi oil (0.908 g/ml), Karanja oil (0.911 g/ml) and their methyl ester (0.856 g/ml and 0.864 g/ml) was observed as quite close to that of diesel (0.849 g/ml). The density of Undi methyl ester was 1.008 times that of diesel where as density of undi oil was 1.069 times of diesel. The density of Karanja methyl ester was 1.017 times that of diesel where as density of Karanja oil was

1.073 times of diesel as shown in Fig. 1.

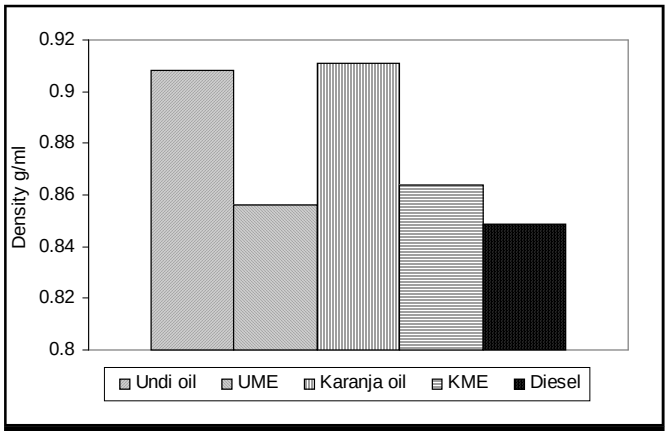

Fig. 1 : Density of different oils and their biodiesel

Specific gravity:

It was observed from Fig. 2 that the specific gravity of Undi oil (0.908), Karanja oil (0.911) and their methyl ester (0.856 and 0.864) was quite close to that of diesel (0.849 g/ml). The specific gravity of Undi methyl ester was 1.008 times that of diesel where as density of undi oil was 1.069 times of diesel. The density of Karanja methyl ester was 1.017 times that of diesel where as density of Karanja oil was 1.073 times of diesel.

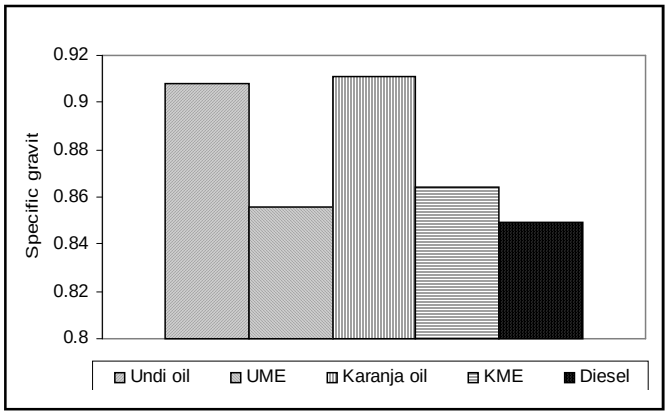

Fig. 2 : Specific gravity of different oils and their biodiesel

Kinematic viscosity:

Fig. 3 represent the Kinematic vacuity of Karanja oil was quite higher than the Undi oil and diesel. Kinematic viscosity of Undi oil was 5.80 cS @ 38 ^{0}C. Kinematic viscosity of Undi oil methyl ester was 3.58 cS @ 38 ^{0}C. Kinematic viscosity of Karanja methyl ester was 6.5, which was 1.12 times that of diesel. Hence, Kinematic viscosity of methyl ester was quite comparable with the diesel.

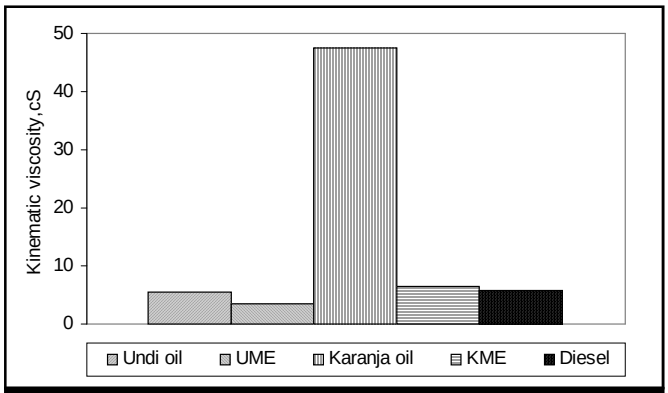

Fig. 3 : Kinematic viscosity of different oils and their biodiesel

Gross calorific value:

It is observed from Fig. 4 that oils had lower gross calorific value compared to that of diesel. The gross calorific value of Undi methyl ester (39.21 MJ/kg) and Karanja methyl ester (35.6 MJ/kg) was quite close to Undi oil (35.55 MJ/kg) and Karanja oil (33.7 MJ/kg) to the respective oils but was quite low (47.4 MJ/kg) compared to that of diesel.

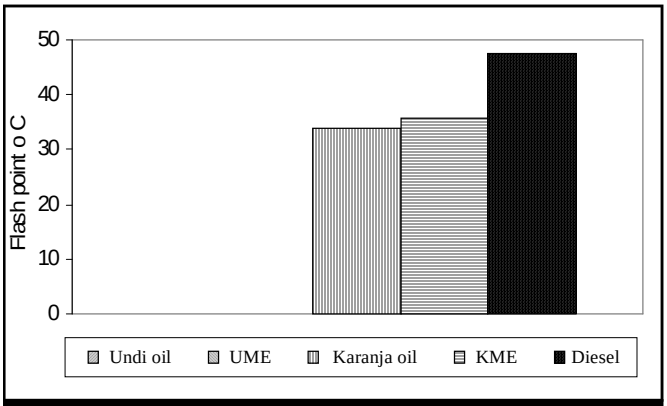

Fig. 4 : Gross calorific value of different oils and their biodiesel

Flash point:

From Fig. 5, it was observed that the flash point of methyl ester was lower than that of their respective oil. The flash point of Undi oil and Karanja oil was 248^0 C and 232^0 C, respectively while the flash point of Undi methyl ester and Karanja methyl ester was 188^0 C and 183^{0}C as shown in Fig. 5. But the methyl ester was much higher flash point than the diesel (47^{0}C). The higher flash point of methyl ester than diesel was attributed to their longer carbon chain.

Fire point:

The fire point of methyl ester was lower than that of

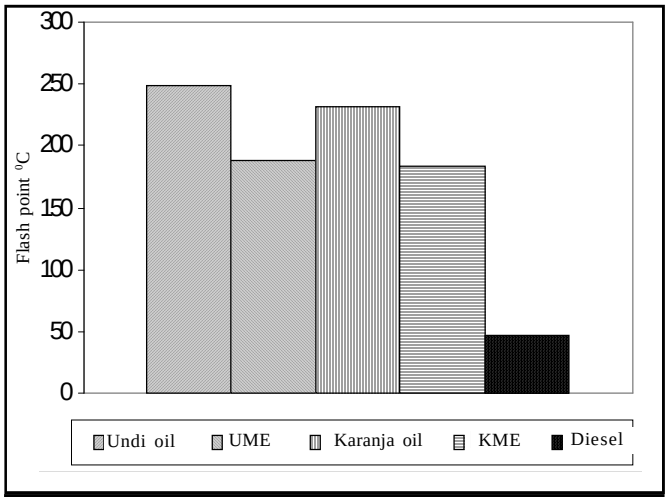

Fig. 5 : Flash point of different oils and their biodiesel

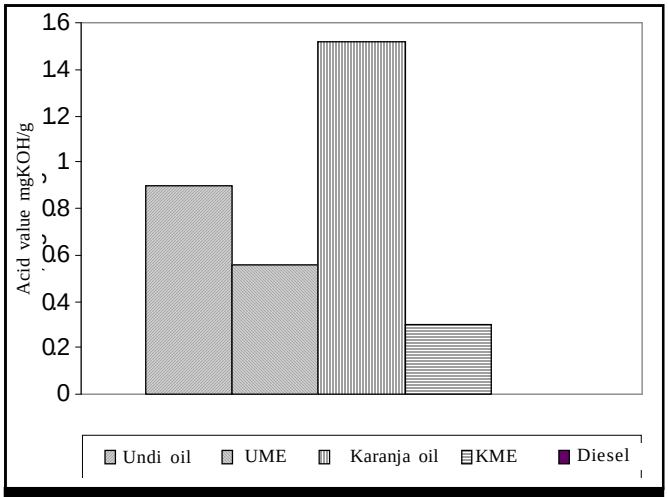

Fig. 7 : Acid value of different oils and their biodiesel

their respective oil. The fire point of Undi oil and Karanja oil was 283^{0}C and 258^{0}C, respectively while the fire point of Undi ethyl ester and Karanja methyl ester was 231^{0}C and 220^{0}C, respectively. But the methyl esters were much higher fire point than the diesel (68^{0}C) as shown in Fig. 6.

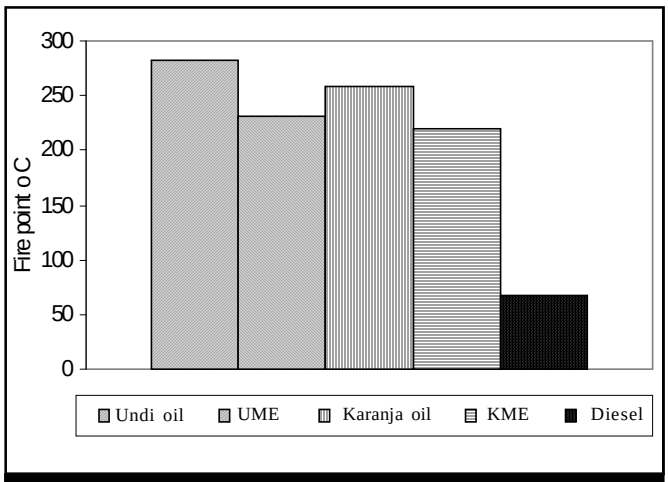

Fig. 6 : Fire point of different oils and their biodiesel

Acid value:

It is seen from Fig. 7 that Karanja oil was highest acid value (1.52 %) followed by Undi oil (0.933 %). On esterficiation the values of acid value reduced drastically and acid value of Undi methyl ester was 0.523 % and Karanja methyl ester was 0.3 %. The value of acid value of diesel oil was zero percentage.

Free fatty acid content:

At elevated temperatures, fatty acids react with metal parts and fatty acid metal could be introduced into the engine cylinder and can increase wear. The percentage of free fatty acid in Undi and Karanja oil are not so high, which could interfere with conversion and recovery of methyl ester. It was seen that Karanja oil had highest FFA (1.5 %) followed by Undi oil (1.2 %). On esterification the values of FFA reduced drastically and FFA of Undi oil methyl ester was 0.66 % and Karanja oil methyl ester was 0.3 %. The value of free fatty acid content of diesel oil was zero percentage shown in Fig. 8.

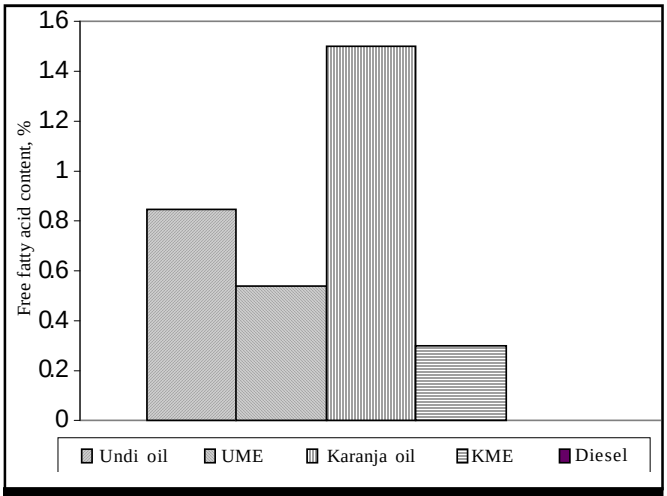

Fig. 8 : Free fatty of different oils and their biodiesel

Saponification value:

Undi oil had highest saponification value (210) followed by Undi oil methyl ester (200.7). On esterification the saponification values reduces. Saponification value of Karanja oil was 191.5 and Karanja oil methyl ester was 187 shown in Fig. 9.

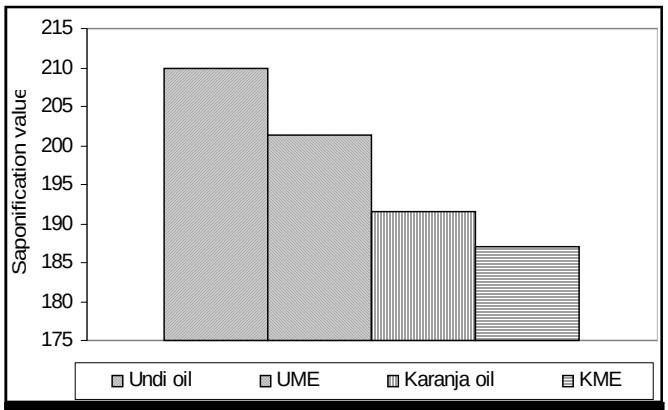

Fig. 9 : Saponification value of different oils and their biodiesel

Conclusion:

– The specific gravity and kinematic viscosity of undi methyl ester were 0.856 and 3.58 cS, respectively.

– Gross calorific value, flash point, fire point, acid value, free fatty acid content and saponification value for Undi methyl ester was found to be 39.21 MJ/Kg, 188^{0}C, 231^{0}C, 0.523 mg KOH/g, 0.66 %, 200.7, respectively.

– Different properties of raw undi oil and its methyl ester were best suitable for methyl ester production.

Authors' affiliations:

P.P. BHOR, K.N. KADAM, S.H. SENGAR AND Y.P. KHANDETOD, Department of Electrical and Other Energy Sources, College of Agricultural Engineering and Technology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, RATNAGIRI (M.S.) INDIA

REFERENCES

Dara, S.S. (1999). *A Text Book on Experiments and Calculations in Engineering Chemwastry*. S. Chand and Company Ltd, Ramnagar, New Delhi: pp. 125–150.

———— *** ————