COMPARISON OF BIODIESEL PROPERTIES PRODUCED FROM *MORINGA OLEIFERA* SEEDS OIL AND PALM OIL

N. A. Eman[1*], A. A. Ahmad Adzhim[2]

[1,2]Faculty of Chemical & Natural Resources Engineering, Universiti Malaysia Pahang, 26300 Kuantan, Pahang, MALAYSIA

ABSTRACT

Biodiesel possess a great potential to help in reducing the dependence on non-renewable fuel which will run out in a near future. Moreover, problems regarding environmental pollution caused from the combustion of fossil fuel and volatile price of this valuable energy had escalated the research and development in production of biodiesel from various feedstocks. This research was conducted to study the effect of different solvent on the yield percentage of extracted oil. Also to produce biodiesel from Moringa oleifera seeds oil and palm oil. Also, to compare the properties of biodiesel produced from these two resources. The Moringa oleifera seeds were crushed and the oil was extracted by solvent extraction process using three different solvent (n-hexane, methanol, and ethanol). The extracted Moringa oleifera seeds oil and palm oil were converted into biodiesel through transesterification process in a presence of methanol and potassium hydroxide as catalyst. As a conclusion, n-Hexane was the best solvent which gives the highest oil yield with an average percentage of 34.3%. The biodiesel properties (such as: cetane number of 66.7, 59.5, kinematic viscosity of 4.8 mm^2/s, 5.04 mm^2/s, cloud point of 18°C, 16°C, pour point 12°C, 7°C, flash point 162°C, 155°C, and density 875 kg/m^3, 890 kg/m^3) produced from Moringa oleifera seeds oil and palm oil, respectively. Moringa oleifera seeds oil had the potential to become a better feedstock to produce biodiesel (MOME) as it possess a better properties compared to biodiesel produced from palm oil (POME).

KEYWORDS: *Biodiesel; moringa oleifera seeds oil; palm oil; solvent extraction; transesterification.*

1.0 INTRODUCTION

The world's fossil fuel reserve is diminishing and become scarce (Demirbas, 2007) due to decades of continuous finding pockets of this valuable so called black gold or fossil fuel, pumping them dry and moving on to new finding. As this trend continues and couple with the imbalance of fossil fuel consumption and production, shrink the amount of non-renewable fuel reserve from undiscovered oil well, make it even harder to discover and more expensive to produce (Harper, Harper, Mayhew, Nightlinger, & Ormsby,2009).

* Corresponding Email: eman@ump.edu.my

This current scenario had triggered scientific communities to seek the best alternative to cope with the problem and meet the ever increase fuel demand by reducing the dependence on petroleum derived fuel and shifting to renewable biofuel that are available, technically feasible, economically viable, and environmentally acceptable (Liaquat, Kalam, Masjuki, & Jayed, 2010) which possess a characteristics of lower emissions of carbon monoxide, particulate matter, and total hydrocarbons which would help to reduce the air pollution.

Biofuels is really an umbrella term and it can mean almost anything, from hydroelectric power, which is generated from waves to wind, solar and other forms of generated energy. However, for the most part the term "biofuels" is used to refer to that of alternative substitutes for petrol, diesel or aircraft fuel. Biofuel can be explained as transportation liquid or gaseous fuels that predominantly produced from biomass (Demirbas, 2006). Biofuels are a viable alternative to fossil fuels and many varieties exist which vary significantly. Some examples are that of biodiesel, which entails growing crops that contain high amounts of natural oil then through a process of hydrogenation or refining a more compatible biodiesel, substitute is created. This creates a biodiesel, which can be mixed with mineral diesel or can be used on its own then used in any diesel-powered automobile.

Biodiesel can be produced from numerous primary feed stocks of either vegetable oils or animal fats such as canola (rapeseed) oil, tobacco oil, jatropha oil, cotton seed oil, sunflower oil, soybean oil, palm oil, peanut oil, rubber seed oil, as well as variety of less common oil (Gerpen, 2005). Nowadays, most of biodiesel being mass produced from same feedstock to produce food and this current situation pose a new threat to food security.

As the demand for biodiesel is steeply rising, the feedstock to produce food is depleting and eventually causing a soar in food price burdening the poor. Hence this research is aimed to find a new feedstock from *Moringa oleifera* seeds oil to substitute today's primary feedstock used by biodiesel producer to produce an environmental friendly biofuel.

Different solvents were used to extract the *Moringa oleifera* seeds oil using thermo electrical soxhelt (Umer, Anwar, Moser, & Knothe, 2008) to find optimum oil yield by using ethanol, methanol and n-hexane. The second goal for this research work was to produce biodiesel from *Moringa oleifera* seeds oil and palm oil. Palm oil and extracted *Moringa oleifera* seeds oil was converted into biodiesel through transesterification process with the presence of methanol and potassium hydroxide as a catalyst (Mamilla, Mallikarjun, & Lakshmi, 2012). The biodiesel produced was analysed for different properties such as: cetane number, kinematic viscosity, cloud point, pour point, density, and flash point and the properties tested were compared with American standards (ASTM D6751) and European standards (EN 14214).

2.0 MATERIALS AND METHOD

2.1 *Moringa oleifera* seeds

Moringa oleifera seeds were obtained from Kota Bharu, Kelantan, Malaysia. The seeds were dehusked and crushed to be used for oil extraction.

2.2 Oil Extraction

About 30 g of crushed *Moringa oleifera* seeds was placed into thimble of soxhelt extractor fitted with 500 ml round-bottom flask and connected with condenser containing 200 ml n-hexane. A heating mantle is set at 60-70ºC, the n-hexane was continuously evaporated and condensed back into thimble containing crushed seeds (Eman, Suleyman, Hamzah, Zahangir, & Ramlan, 2010; Trakarnpruk and Chuayplod, 2012). The same procedure was followed using methanol and ethanol. The oil was recovered by placing the oil mixed with solvent into rotary evaporator under vacuum at 70ºC. The cake residue was collected and dried at 50ºC for 1 hour and the weight of the cake residue was recorded to calculate the produced oil yield.

2.3 Preparation of Catalyst

In this research, the molar ratio of vegetable oil to methanol was 6:1 (Moftijur, et al., 2014). In order to prepare the chosen molar ratio, about 0.5 g of potassium hydroxide was diluted in 50 ml of methanol. The mixture is heated up to 30ºC until the potassium hydroxide was completely dissolved.

2.4 Pre- treatment of Crude Palm Oil

The crude palm oil was collected from (Kilang Sawit Lepar Hilir 3, Gambang, Pahang, Malaysia) with low grade. Therefore, pre-treatment was carried out to remove any unwanted solid particles; the crude palm oil was centrifuged at 5000 rpm for 15 minutes. The pre-treatment continued with bleaching with 6 g of fuller earth bleaching agent which is poured into beaker containing palm oil and stirred for 30 minutes at 100ºC. The mixture was left to cool down and centrifuged once again at 5000 rpm for 15 minute to get a clean and clear palm oil.

2.5 Transesterification

The *Moringa oleifera* seeds oil was converted into methyl ester (MOME) using methanol in a 1 litre round-bottom flask with a reflux condenser. The mixture was stirred using magnetic stirrer at 400 rpm and heated to 60ºC for 1 hour. The same procedure was followed for palm oil transesterification process.

After 1 hour of transesterification process, the mixture was poured into separator flask and left for at least 12 hours (Predojevic, 2008). Two layers were formed in separating flask, the lower layer was glycerol and some unwanted product and the upper part was biodiesel.

The washing stage was carried out to remove glycerol using deionized water heated at 55ºC. The mixture was left to settle in a separator funnel for 12 hours, two layers were formed (lower layer was water + glycerol and the upper layer was biodiesel). The lower part was removed and biodiesel was continuously washed until the drain water was clear with neutral pH. To remove excess water from biodiesel, it was stirred with 4 g of florosil for 30 minutes and centrifuged at 5000 rpm for 15 minute.

2.6 Biodiesel Properties

The properties of biodiesel produced from *Moringa oleifera* seeds oil and palm oil were determined using specific methods. Cetane number is determined using American Standard Testing Methods D6890 (ASTM D6890). Implementing ASTM D445 and Cannon–Fenske viscometers is used to obtain the kinematic viscosity. Cloud and pour point determinations were conducted with a Phase Technology (Richmond, BC, Canada) cloud and pour point by freeze point analyser. Density was determined by ASTM D4052. Flash point was determined using Pensky-martens flash point – automatic NPM 440 (Normalab, France) by implementing ASTM D93 standard.

3.0 RESULTS AND DISCUSSION

3.1 Effect of different solvents on oil extraction

The oil extraction from *Moringa oleifera* seeds was performed using three solvents (n-Hexane, Methanol, and Ethanol). Oil yield % was calculated using equation: $W_o - W_1 / W_o$ X 100, where: W_o is the weight of raw *Moringa oleifera* seeds, W_1 is the weight of *Moringa oleifera* cake residue. The results of oil yield using different solvents are shown in Table 1. It can be concluded that the highest oil yield of 34.3% was achieved using n-hexane.

Table 1. Oil yield from *Moringa oleifera* seeds using different solvents

Solvents	**Solvent volume (ml)**	**Weight of seeds (g)**	**oil yield (%)**			
			Batch 1	**Batch 2**	**Batch 3**	**Average**
Methanol	200	30	16.2	17.5	15.7	16.5
Ethanol	200	30	18.9	19.8	20.8	19.8
n-Hexane	200	30	33.2	34.5	35.1	34.3

3.2 Biodiesel Propeties

The differnt properties of MOME and POME were measured according to the standard methods used for biodeisel:

3.2.1 Cetane Number

Cetane number was determined using Ignition Quality Tester. The test was repeated three times using 50 ml of biodiesel to get the average value and the result was tabulated in Table 2. Based on the results, biodiesel produced from *Moringa oleifera* seeds oil possessed a higher cetane number which was 66.7 compared to biodiesel produced from palm oil which was 59.5. This high cetane number will help to ensure low carbon release footprint, improved fuel efficiency and reduce tear and wear for both vehicle starter and batteries (Masina, et al., 2012).

3.2.2 Kinematic viscosity

Kinematic viscosity was done to find out which biodiesel is able to flow easily under pressure. According to ASTM D445 standard, viscosity tube number 350 was used to measure the kinematic viscosity and about 30 ml of biodiesel was needed to complete the test. The average kinematic viscosity for biodiesel produced from *Moringa oleifera* seeds oil and palm oil was 4.8 mm^2/s and 5.04 mm^2/s, respectively as shown in Table 2. Thus, it can be concluded that *Moringa oleifera* seeds oil had a lower kinematic viscosity value compared to palm oil biodiesel.

3.2.3 Cloud and Pour Point

The cold flow properties of biodiesel are characterized by Cloud Point (CP), Cold Filter Plugging Point (CFPP) and Pour Point (PP) (Rajagopala, Bindu, Prasad, & Ahmad, 2012). The CP is the temperature at which the fuel shows a haze due to crystals formation. The CFPP is the temperature at which the crystals formed will cause the plugging of the filters. The PP is the lowest temperature at which the liquid will flow (Soriano, Migo, Sato, & Matsumura, 2005).

About 50 ml of biodiesel was poured into test tube until it reached the level indicator on the test tube. The sample was placed inside a refrigerator and observed for every one minute until solid-crystals appeared. The cloud and pour point for *Moringa oleifera* biodiesel were 18ºC and 12ºC and for palm oil biodiesel were 16ºC and 7ºC, respectively (Table 2). Although cloud and pour point for *Moringa oleifera* biodiesel is slightly higher compared to palm oil biodiesel, the high content of saturated ester which possess higher melting point than saturated fatty acid in palm oil biodiesel seem to compensate as the cold flow properties for biodiesel are determined based on the amount of higher melting component and not their nature (Imahara, Minami, & Saka, 2006).

3.2.4 Flash Point

Flash point was crucial to be tested to compare with the classification of the Department of Transportation (DOT) regulations. It is used in shipping and safety regulations to define flammable and combustible material. The flash point was 162ºC and 155ºC for *Moringa oleifera* biodiesel and palm oil biodiesel, respectively (as shown in Table 2), which were higher than that for petroleum diesel (approximately 70ºC). Therefore, it is much safer to handle and transport the produced biodiesel from *Moringa oleifera* biodiesel and palm oil biodiesel. Moreover, The Flash Point is also used to ensure the residual methanol left in the fuel after biodiesel processing which will not negatively affect combustion and other fuel system components.

3.2.5 Density

Density is a fuel property which directly affects the engine performance characteristics. Many performance characteristics, such as cetane number and heating value, are related to the density. On the other hand, diesel fuel injection systems measure the fuel by

volume. So the changes in the fuel density will influence engine output power due to a different mass of fuel injected. The density and viscosity of the fuels affect the start of injection, the injection pressure, and the fuel spray characteristic, so that they influence the engine performance, combustion and exhaust emissions (Alptekina and Canakcia, 2008). Density for *Moringa oliefera* biodiesel and palm biodiesel was 875 kg/m^3 and 890 kg/m^3, respectively as shown in Table 2.
The biodiesel produced from *Moringa oleifera* seeds oil and palm oil is shown in Figures 1 and 2, respectively.

Table 2. Biodiesel properties produced from *Moringa oleifera* seeds oil and palm oil

Properties	***Moringa oleifera* biodiesel**				**Palm oil biodiesel**			
	1	**2**	**3**	**Average**	**1**	**2**	**3**	**Average**
Cetane number	66.7	66.8	66.7	66.7	59	59.5	60	59.5
Kinematic viscosity (mm^2/s; 40^o C)	4.8	4.7	4.8	4.8	5.06	5	5.06	5.04
Cloud point (^{o}C)	18	18	18	18	16	16	16	16
Pour point (^{o}C)	12	12	12	12	7	7	7	7
Flash point	160	162	163	162	154	155	155	155
Density (kg/m^3)	875	875	876	875	890	890	891	890

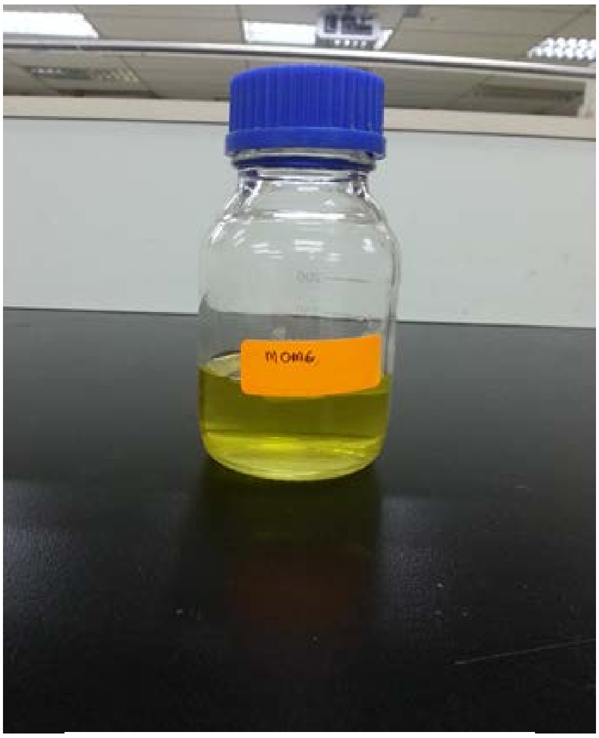

Figure 1. *Moringa oleifera Biodiesel*

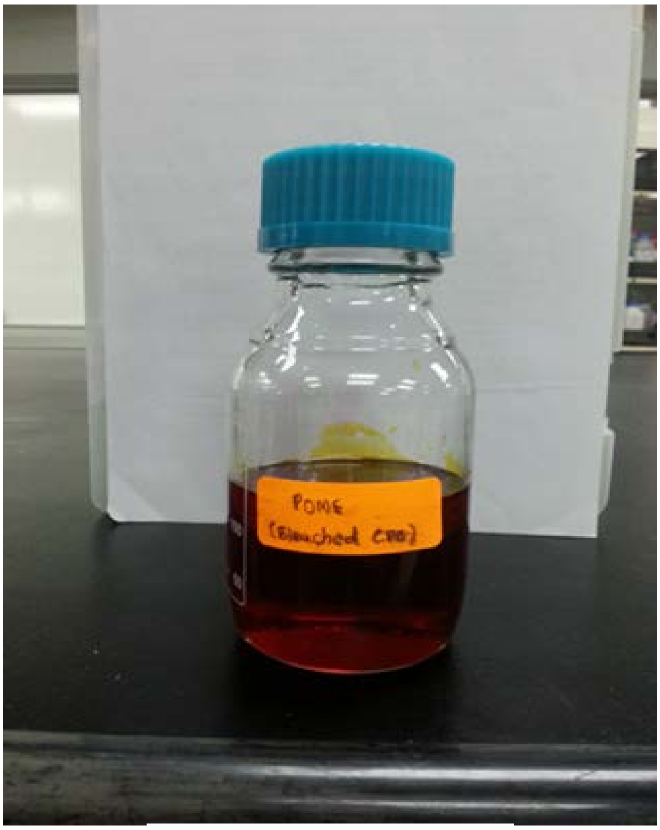

Figure 2. *Palm Oil Biodiesel*

The biodiesel properties produced from *Moringa oleifera* seeds oil (MOME) and palm oil (POME) were compared with American standards (ASTM D6751) and European standards (EN 14214) as shown in Table 3.

Table 3. Produced biodiesel properties compared with biodiesel standards

Properties	**MOME**	**POME**	**ASTM D6751**	**EN 14214**
Cetane number	66.7	59.5	47	51
Kinematic viscosity (mm2/s; 40°C)	4.8	5.04	1.9–6.0	3.5–5.0
Cloud point (°C)	18	16	-	-
Pour point (°C)	12	7	-	-
Flash point (°C)	162	155	130	120
Density (kg/m^3)	875	890	870-900	860-900

4.0 CONCLUSION

Based on results in Table 1, best solvent for *Moringa oleifera* oil extraction was n-hexane which yields about 34.5% of oil. According to the results obtained in Table 3, the better biodiesel can be derived from *Moringa oleifera* seeds oil which possesses a better properties than biodiesel produced from palm oil, it has a high possibility to become a main feedstock in the production of biodiesel with a competitive price. Biodiesel from *Moringa oleifera* seeds oil also will help to prevent food crisis, palm oil-based food price hiking and reduce the tension to palm oil producer. Moreover, this study will help to start commercialise the plantation of *Moringa oleifera* tree in Malaysia. Thus, generating sustainable income, with more job opportunities, and new crop to be considered for more economical value.

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