BIODIESEL FROM NON-EDIBLE MALAYSIAN FRUITS.

Farid Nasir Ani and Mohd Fadzli Jais

Mechanical Engineering Department, Universiti Teknologi Malaysia

ABSTRACT

Limited supply of petroleum resources, global warming issues and increasing yearly prices of petroleum in the present time, motivated human to search for new alternative of energy sources. Utilization of edible oil like vegetable oils as fuel actualized the competition between human needed in food consuming and desired in life. Consequently, this study intended to investigate the feasibility of utilization of non-edible oil as new renewable sources of energy to reduce the depended on fossil fuels. The study examined the aspects of the properties and engine performances of Sea Mango (*Cerbera Odollam*) seeds oil which blended with various percentage of Malaysian petroleum diesel fuel. In Malaysia, Sea Mango trees were planted as decorated tree along the roadside and around housing areas. It shows the potential of 40-60 % of extracted oil from dried seeds through solvent extraction technique. Engine performances will be presented with various blends of diesel fuel. At the end of the study, the some fuel characteristic will be compared to diesel fuel and its feasibility as new source of energy will be discussed.

1. INTRODUCTION

Many researches in Malaysia are focussing on application of palm oil as biodiesel fuel due to its commercial value. However, the ignorance of other plants that are available and have potentials, easily found and not commercial at present, should not be exploited. Wild plants such as Jatropha Curcas are now been cultivated in Indonesia, India and Cambodia. This study intended to investigate the feasibility of utilisation of non-edible oil as new renewable sources of energy to replace the edible seed oils. The non-edible fruit that have been chosen is Sea Mango (*Cerbera Odollam*). Its poisonous properties and non-seasoning fruits make Sea Mango are always available. The study examined the aspects of engine performances of Sea Mango seeds oil (SMSO) which is blended with various percentage of Malaysia petroluem diesel fuel. In Malaysia, Sea Mango trees were planted as decorated trees along the roadsides and around the housing areas.

Biodiesel fuels and its blends are describe as to reduce gaseous emissions, excellent engine fuel with clean burning, efficient energy, non-toxic and directly can be used in diesel engines without major modification and offer other advantages. Application of biodiesel is seem to be practical for future fuel due to the limited supply of petroleum diesel.

Research and development of biodiesel is important in order to minimize the dependence of diesel fuel. Most biodiesel fuels have faced the problems, especially operating effectively in cold weather. The performance of the non-edible oil as alternative fuels can be observed through combustion process. In this study, the combustion of biodiesel from non-edible oil, is applied to the direct injection diesel engine.

2. METHODOLOGY

2.1 Preparation of Seed Oil and Characterisation

Cerbera Odollam were planted in Malaysia as the decorate trees along the roadsides and as landscape plants in housing areas. The fruits were collected around the housing areas nearby the university. The ripe fruits were dried and the seeds were separated from the mesocarps. The fresh seeds were cut to reduce the size and then were dried in oven for 8 hours continuously. Care should be taken in handling the Cerbera fruit seeds that contains toxic content (*Glycoside Cerberin*). After drying, the seeds were ground and prepared for oil extraction. The extraction method of sea mango crude oil is Soxhlet Extraction. Sea mango seed oil was obtained from the dried sea mango seed through the solvent extraction technique.

After the crude oil was produced, the process of utilising biodiesel was prepared. Basically, the utilisation of seeds oil as biodiesel can be categorized in three type. First, the sea mango seeds oil (SMSO) could be blended with diesel fuel in percentage by volumetric. Secondly, by using transesterification process through the presence of catalyst and thirdly, by using it straight, the neat seeds oil as alternative fuels. However, in this study, the first method were used due to the initial investigation of its feasibility as alternatives fuel. Besides, converting to methyl ester will consume more funds and meanwhile using directly of the neat oil required more feedstock of the extracted oil.

Figure 1: The Sea Mango seeds and its Oil

The seeds were ground to increase the surface area when contact with solvent during extraction process. According to Nathan, (1985) the more dried the seed, the more oil it could be extracted due to reduction of moisture content of the seeds.

In this study, four test fuels were prepared including D2 as the reference fuel. The tested fuels are B5, B10, B20 and D2 is the Malaysian Petroleum Diesel. The biodiesel were prepared by volumetric proportion between sea mango seed oil and diesel fuel. B5 stands for 5 percents of Sea Mango Seeds Oil (SMSO) and 95 percents of diesel fuel. The blended biodiesel were prepared by stirring the mixtures for 1 hour and then been heated at 50 °C. The heating process is important in order to ensure that the fuel is completely mixed.

2.2 Engine Test Facilities

The engine performances were carried out using Detroit, two cylinder, diesel engine with 108 mm engine bore, stroke 127 mm and compression ratio of 17:1. Froude DP3 hydraulic dynamometer was coupled on to the engine to indicate the reading of the engine speed in effect of engine load. Six different loads (0.5, 1.5, 2.0, 2.5, 3.0 kg) were test at constant engine speed of 1200 rpm and 1400 rpm for each test fuel. The times taken for the consumption of 50cc fuel and engine speeds were recorded for the engine performances.

3. RESULTS AND DISCUSSIONS

3.1 Characterizatics of the Fuel Properties

The percentage of oil extracted from the dried Sea Mango is about 44.1%, meanwhile for fresh seeds the extracted oil is up to 4%. Dried seed gives more percentages of oil extracted compare to fresh seeds due to the content of moisture in the seeds. To release as much oil as possible, the seeds must be dried to lower moisture content and exposure to high ambient temperature (Nathan 1985).

The densities of blended fuel are slightly higher than diesel fuel. Higher densities of sea mango crude oil causes the density of blended fuel to increase. As a result, the 5 % blends increase 0.238 %, 10 % blends increases 0.52 % and 20 % blends increases 1.273 % from the density of diesel fuel. The pour point of Sea mango crude oil is relatively lower than diesel and lower value of this point enable the sea mango to run in low ambient temperature. The blends of SMSO show that with increasing percentage of SMSO the pour point become lower, meanwhile there is no much different in cloud point. Since the value of blends fuel pour point are lower, then its viscosity is comparable with diesel. High viscosity of oil will give effect to the spray characteristic of the fuel because its influences on fluidity.

Table 1: Fuel Properties at Various Blended of Diesel

Properties	D2	B5	B10	B20
Heat Value, (kJ/kg)	44891.66	44877.7	44849.79	44784.6
Cloud point, (°C)	14-16	9	10	8
Pour Point, (°C)	12	8	4	2
Density @ 15 °C (kg/l)	0.8494	0.8504	0.8525	0.8566
Specific Gravity	0.8499	0.8509	0.8529	0.8571
Density@ 27°C, (kg/m ^{3})	829.8	831.24	833.48	839.72

3.2 Engine Performances of Blended Biodiesel and Diesel Fuel

The results of engine performances were evaluated to investigate each tested fuel performances in Detroit Diesel engine. In this study, brake specific fuel consumption has been use as an indicator to compare fuel economy within the different percentage of SMSO. The fuel performances for each blended were investigate by study the effect of variation engine speed at constant load, the effect of different load on brake specific fuel consumption at constant engine speed and thermal efficiency. Two constant engine speeds have been test to compare brake specific fuel consumption and thermal efficiency at different load applied.

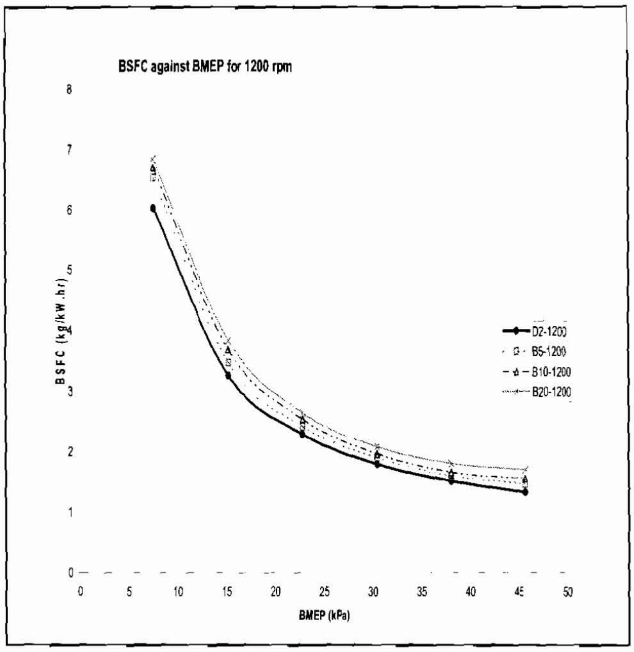

Figure 2: Effect of BSFC against BMEP at engine speed of 1200 rpm

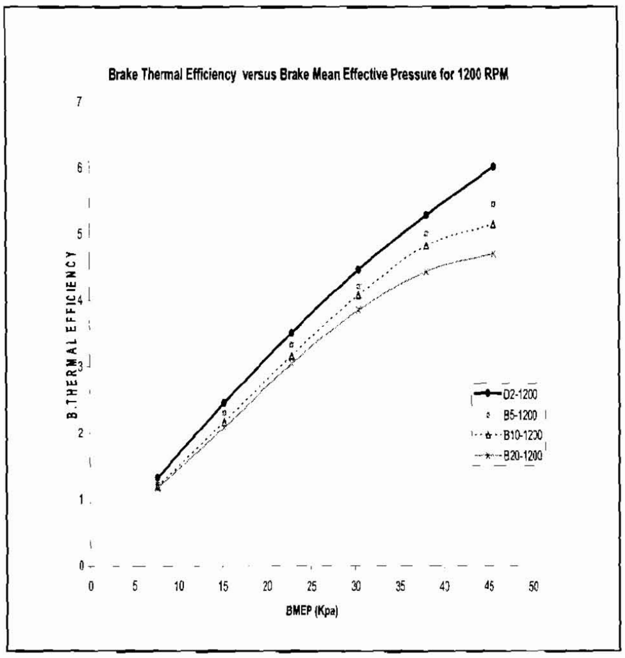

Figure 3: Effect of Brake Thermal Efficiency against BMEP at engine speed 1200 rpm

Figure 2 of blended biodiesel shows similar trend of specific fuel consumption compared to diesel. The fuel consumption of various blended biodiesel is slightly higher than diesel fuel for all range of applied load. The maximum increasing of fuel consumption occurs when the highest load apply at constant engine speed. The maximum increment (percentage) of each tested fuel (B5, B10 and B20) as compared to diesel are 10.4 %, 16.9 % and 28.3 % meanwhile lower load are: 8.3 %, 11.18 % and 13.46 %.

Higher percentage of blended biodiesel will result in higher increment of fuel consumption compared to diesel fuel. Higher percentage of blended biodiesel will increased the value of specific gravity and reduce the value of calorific for each test fuel. It was due to the restructured of molecule in blended biodiesel fuel. Blending palm oil with conventional diesel changes fuel physicochemical properties, including viscosity, cloud point, cetane number, heat value and boiling point (Azhar, 2005). Biodiesel with lower amount of heat value will give effect to more specific fuel consumption. That is understandable as biodiesel have lower heat value as it needs more fuel to maintain the same brake specific fuel consumption at a given load.

The graph of blended biodiesel shows same trends of brake thermal efficiency as compared to diesel. The thermal efficiency of various blended biodiesel is lower than diesel fuel for all range of applied load. The maximum reduction of thermal efficiency occurs when the highest load is applied at constant engine speed. The maximum percentage reduction of each test fuel compared to diesel at high load are 9.5 %, 14.4 % and 21.86 %. The higher percentage of blended biodiesel will result to higher reduction in thermal efficiency compared to diesel fuel.

The results were affected by the amount of heat value for each test fuel. Diesel fuel has the highest heat value and more fuel energy can be converted into the engine output as compared to the other blended biodiesel. It can be seen that more thermal power generated by increasing the heat value. At medium and high ranges of applied load, the graph shows more reduction in thermal efficiency as compared to diesel fuel. At these ranges, more fuel were consumed as to maintain the brake power and thermal power. This will reduced the thermal efficiency.

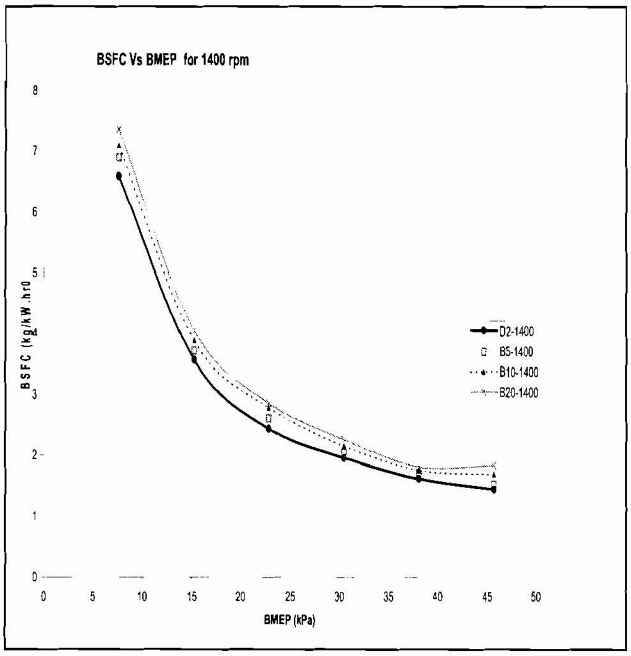

Figure 4: Effect of BSFC against BMEP at engine speed 1400 rpm

Figure 4 shows the brake specific fuel consumption against brake mean effective pressure for engine speed 1400 rpm. Basically for the entire load applied, increasing percentage of Sea Mango seeds oil will increase the BSFC with maximum increasing 26.8 % from reference fuel. The graph has been plotted for BMEP to enable comparison with dissimilar engines. Basically, increasing load to the engines will cause the engines to increase fuel consumption rate in order to maintain same brake power. Figure 4 show that the BSFC for B5 and B10 at 1400 rpm increased with the increasing of SMSO percentage meanwhile the heat value were decreased. Therefore more fuel was used to maintain the brake effective pressure.

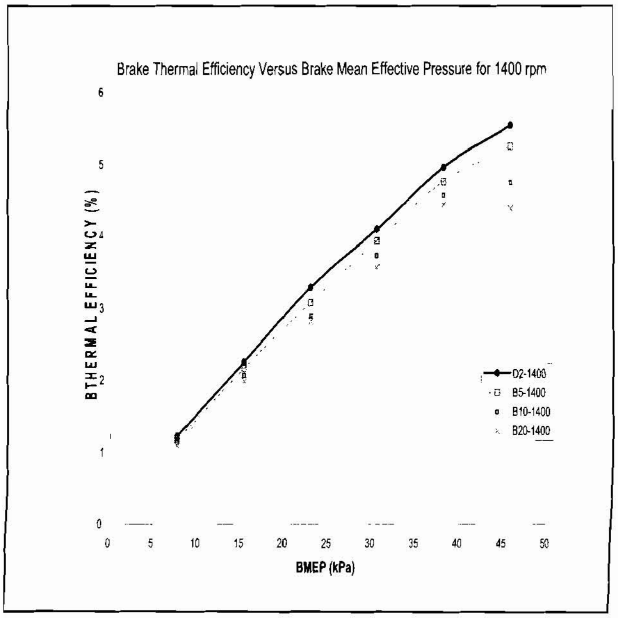

Figure 5: Effect of Brake Thermal Efficiency against BMEP at engine speed 1400 rpm

Figure 5 shows similar trend at lower to medium load applied, however at high load applied it show some different. At lower load, there are no significant different between blended biodiesel and diesel fuel. Thermal efficiency of biodiesel was reduced at high load applied and with maximum reducing is 20.9 % from diesel fuel. As mentioned before, more fuel will be consumed when higher load is applied and lower heat value of biodiesel causes the thermal efficiency to reduced. For 5 % blended, it shows that reducing of thermal efficiency at 5.3 % meanwhile at 10 % blended it show 14.3 % different to diesel fuel.

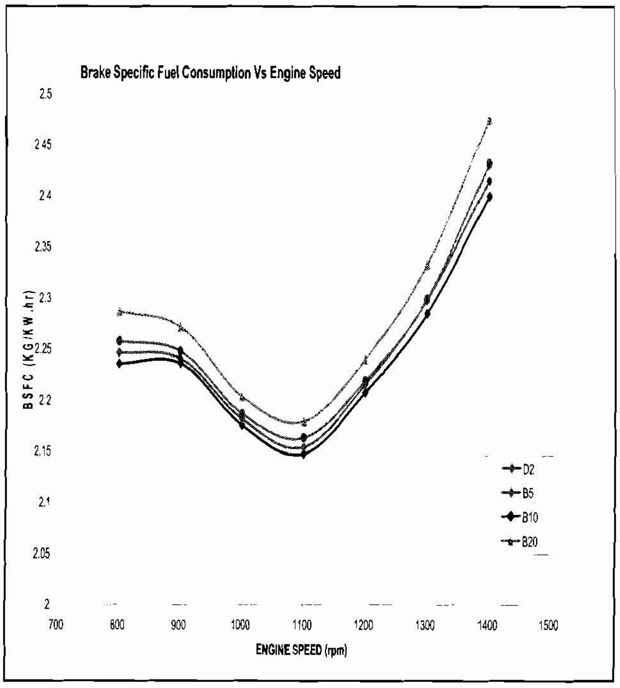

Figure 6: Graph BSFC against Engine Speed at Constant Torque 8.46Nm

Figure 6 shows the graph of BSFC against engine speed when same torque was applied to the engine. Varying the engine speed causes the BSFC to increase. From the figure, it shows, at engine speed 1100 rpm (medium) was recorded as the minimum value of BSFC for all ranges of test fuel. From medium to high engine speed it show increasing BSFC of biodiesel from 0.3 % to 3.13 % meanwhile at medium to lower engine speed, it show increasing from 0.3 % to 2.2 %. Biodiesel have lower heat value compared to diesel and this is the factor that cause the different in fuel consumption at various engine speed.

Table 2: Percentage Different of BSFC at Various Engine speed

Percentage Different of BSFC of Biodiesel and Diesel Fuel							
ENGINE SPEED (rpm) / FUEL TYPE	800	900	1000	1100	1200	1300	1400
B5 (%)	0.4747	0.2019	0.2889	0.3064	0.360	0.5879	0.652
B10 (%)	0.9717	0.5201	0.5201	0.7326	0.520	0.6269	1.330
B20 (%)	2.2746	1.5769	1.2858	1.4868	1.464	2.1031	3.129

CONCLUSION

The percentage of crude oil extracted from the dries sea Mango Seed is up to 41.1% with heat value of 44,045 kJ/kg. BSFC for bio-diesel were slightly increases than diesel fuel. Sea mango seeds oil show that crude oil of sea mango seeds has high density (0.8950 kg/l) compare to diesel and the heat value is lower than diesel. However, if comparing the heat value of Jatropha and Palm oil, sea mango has the highest heat value.

Laboratory tests of blended biodiesel from 5 % to 20 % by volume shows that heat values of blended fuels were slightly reduced (< 2 %) compared to conventional diesel. Density for sea mango blends show increasing value when percentage of sea mango seed oil increases in the blends. The blended fuels have been successfully run into unmodified diesel engines and fuels performances have been evaluated. It is found that increasing of sea mango percentage will increase the BSFC for entire load apply especially at highest load. BSFC for B5, B10 and B20 increased from 0.2 % to 3.3 % at higher engine speed with same load applied. For constant speed and different load applied show that BSFC increases from 10.4 % to 28.3 % at 1200 rpm. Meanwhile at 1400 rpm BSFC increases from 5.59 % to 26.8 %.

For brake thermal efficiency, biodiesel fuels provide similar trend with diesel at lower to medium load applied. At higher load, the thermal efficiency of biodiesel were slightly lower than diesel fuel. This phenomenon occurs due to lower calorific value between diesel and biodiesel. The result show that maximum reduction of brake thermal efficiency at higher load is 21.8 %(1200 rpm) and 20.9 % (1400 rpm). At lower load the brake thermal efficiency were close resemble between biodiesel and diesel fuel. As summary, calorific value of biodiesel is slightly lower as compared to diesel and this will cause increasing of BSFC and reducing of brake thermal efficiency. However, biodiesel have been successfully run into unmodified diesel engines and show potential as new source of energy. Converting into methyl ester will seem as the best manner to remove impurity due to free fatty acid and make the density and other properties approximately with diesel.

REFERENCES

Azhar Abdul Aziz (2005). *Performance of Palm Oil-Based Biodiesel Fuels in a Single Cylinder Direct Injection Engine.* Universiti Teknologi Malaysia

Biodiesel Handling and use Guidelines, US Department of Energy (2006).

Cheng Sit Foon (2005). *Palm Biodiesel: Gearing Towards Malaysian Biodiesel Standards.* Malaysian Palm Oil Board.

Foo Yu Suen, (2007). *Utilization of Non-Edible Fruit as Diesel Fuel.* Universiti Teknologi Malaysia.: Bachelor of Engineering.

Nathan (1985), Understanding Solvent Extraction of Vegetable Oils.

Pramanik (2001). *Properties and Use of Jatropha Curcas Oil and Diesel Fuel Blends in Compression Ignition Engine.* Department of Chemical Engineering, Calicut.

Ramadhas A.S. (2004). *Biodiesel production from high FFA rubber seed oil,* Department of Mechanical Engineering, National Institute of Technology Calicut, Calicut 673 601, India

Sureshkumar, *(2006). Performance and exhaust emission characteristics of a CI engine fueled with Pongamia pinnata methyl ester (PPME) and its blends with diesel.* Crescent Engineering College, Vandalur, Chennai 600048, India

Farid Nasir Ani received the B.Sc. (1982), M.Sc(Eng). (1985), and PhD. (1992) degrees in Mecchanical engineering from Glasgow University, Birmingham University and Leeds University, United Kingdom respectively

He is a Professor, Department of Mechanical Engineering, Universiti Teknologi Malaysia, Johor D. T., Malaysia. His Current interests include Biomass Thermal Chemical Conversion, Fuel, Energy and Combustion.

Mohd Fadzli Jais received B.Eng. (2007) degrees in Mechanical engineering from Universiti Teknologi Malaysia.