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# PERFORMANCE EVALUATION OF CASTER METHYL ESTER IN DIRECT INJECTION FOUR STROKE DIESEL ENGINE

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## Abstract
This paper presents the results of investigations carried out in extracting, transesterifying, studying the fuel properties of Castor oil Methyl Ester (CME) and its blend with diesel fuel and in running a diesel engine with these fuels. Engine tests have been carried out with the aim of obtaining comparative measures of torque, power, and specific fuel consumption. In this research, castor oil was extracted by using a mechanical pressing machine, transesterified by using methyl alcohol and potassium hydroxide as a catalyst so that its viscosity and density are reduced and its volatility is increased and can be used in the existing diesel engines without requiring extensive modifications. The fuel characteristics were studied following the standard procedures given in ASTM book so that whether it fulfills the requirements needed to be used as a fuel in internal combustion engines or not. From the characterization result, it was proved that transesterified castor oil was found to be a promising alternative fuel for compression ignition (diesel) engines. But the viscosity of CME is still higher and the energy content is a little bit less as compared to petrodiesel. To solve these problems CME was blended with petrodiesel in some proportion (B5, B10, B20, B40, B80). The torque, power and brake specific fuel consumption performances of CME and its blends with petrodiesel were tested in a four stroke diesel engine, analyzed and compared with that of petrodiesel and found to be very nearly similar making CME a suitable alternative fuel for petrodiesel.

***Keywords—***Characterization, CME, Diesel engine, Performance evaluation, Transesterification.

## 1. Introduction
Biodiesel is an alternative fuel produced from vegetable and tree oils, animal fats, or used cooking oils and fats, that can be used as a substitute for, or an additive to, conventional diesel fuel. Biodiesel has a higher Cetane Number with other characteristics similar to diesel fuel, thus it can be used in diesel engines without any modifications. Since it is produced from renewable and domestically grown feed stocks, it can reduce the use of petroleum based fuels and possibly lower the overall greenhouse gas contribution from the use of internal combustion engines. Biodiesel, due to its biodegradable nature, and essentially no sulfur and aromatic contents, offers promise to reduce particulate and toxic emissions, and is considered to be an attractive transportation fuel for use in environmentally sensitive applications such as urban buses in heavily polluted cities, national parks and forests, marine areas, and underground mining equipment. It is also reported that adding small amounts of biodiesel to conventional diesel can improve fuel lubricity, extend engine life, and increase fuel efficiency (Peterson, C.L. 1986).

The large increase in number of automobiles in recent years has resulted in great demand for petroleum products. With crude oil reserves estimated to last for few decades, there has been an active search for alternate fuels. The depletion of crude oil would cause a major impact on the transportation sector**.** Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils or animal fat, is the most promising alternative fuel to petro diesel (G. Knothe et al 2005).

Vegetable oils have long been promoted as possible substitutes for diesel fuel. Historical records indicate that Rudolph Diesel, the inventor of the diesel engine, used vegetable oil in his engine as early as 1900. Castor oil was used in the first diesel engine in Argentina in 1916. Gauthier, a French engineer, published a paper in 1928 discussing the use of vegetable oils in diesel engines. Interest in vegetable oils continued in various parts of the world during the Second World War, but later on, the arrival of peace and the relative abundance of inexpensive fossil fuels made research into diesel substitutes unnecessary. The OPEC embargo of the 1970's and the subsequent rise of fuel prices and the fear of fuel shortages revived the interest in alternative fuels, including vegetable oils as fuel for diesel engines. However, the high viscosity of vegetable oils, which results in poor fuel atomization and fuel injector blockage, makes them best used after conversion to vegetable oil esters which are commonly known as biodiesel. Recent environmental and domestic economic concerns have prompted resurgence in the use of biodiesel throughout the world. In 1991, the European Community (EC) proposed a 90% tax deduction for the use of biodiesel. Biodiesel manufacturing plants are now being built by several companies in Europe; each of these plants producing about 5.0 million liters of fuel per year. In the United States (U.S.) and Canada, the interest in biodiesel is also growing. Several demonstration programs in North America are using biodiesel to fuel many vehicles, including buses, trucks, construction and mining equipment, and motor boats. Research in using biodiesel to enhance the lubricity of diesel fuel is also underway (G. Knothe et al 2005).

# 2. Experiments

### *2.1. Extraction of Oil*

The method used to extract the oil was mechanical pressing of the castor seed by a human operated hydraulic pressing machine which was developed by the Bako Agricultural Research Mechanization, Ethiopia.

### *2.2. transesterification of castor oil*

Transesterification (also called alcoholysis) is the reaction of a fat or oil triglyceride with an alcohol to form esters and glycerol. Transesterification of castor oil is comprised dissolving of KOH (2grams) in methyl alcohol (100ml), heating of castor oil (100ml) to $50^0$C, adding KOH and methyl alcohol solution (25ml) in to the heated oil, stirring of the mixture, separation of glycerol, washing with distilled water and addition of $Na_2SO_4$ for drying of water (J. Van Gerpen et al). Castor oil was transesterified using the esterification system developed in the laboratory of the Wondogenet Agricultural Research Center (Essential oil producer's laboratory), Addis Ababa, Ethiopia.

### *2.3. Characterization of castor seed derived biodiesel*

Characterization is the process of determining the physiochemical properties of petroleum products or mixture of petroleum and non petroleum products like biodiesel blends. Before testing the performance of the produced fuel in diesel engines, it is very important to know its physiochemical properties. These properties of the fuel include viscosity, density, cetane number, cloud and pour points, distillation range, flash point, ash content, carbon residue, acid value, copper corrosion, SN, IV and higher heating value (*ASTM International* 2002).

Characterization of the fuel to be tested in this research work was done in the laboratory of Ethiopian Petroleum Enterprise (EPE) following the procedures given in the book of ASTM 1, 2, 2002. In this research project the fuel properties of B100 (neat), B80, B40, B20, B10, B5 (a blend of 80%, 40%, 20%, 10%, 5% biodiesel and 20%, 60%, 80%, 90%, 95% petrodiesel respectively) and petrodiesel (B0) are studied.

### *2.4. Performance testing*

In this stage of the research, the performance of the fuel was measured in the Performance testing setup prepared. The blends which fulfill the ASTM standards for biodiesel in the characterization stage and the base fuel (petrodiesel) which was used as a performance comparator for the blends were tested. The blends that pass the ASTM standards were B5, B10, B20 and B40. Torque, Power and Specific Fuel Consumption (SFC) of each blend was compared with that of petrodiesel.

The following were the test procedures followed.

- The engine was warmed up to its operating temperature before starting the test.
- Using the RPM adjuster the fuel rack was set (60%) to a speed of 3500 rpm.
- Then the load was gradually increased by the load adjuster and torque, speed and fuel flow rate are registered at equal intervals of load variation.
- The engine performance characteristics (torque, speed and fuel flow rate) were monitored within the speed range of 1200 rpm and 3500rpm.

Following the above procedure, 1st the base fuel (B0) performance was done and then follows the blend fuels (B5, B10, B20 and B40). The brake power $\mathbf{P_b}$ in watts delivered by the engine and absorbed by the dynamometer is calculated from the brake torque and angular speed. The fuel consumption is measured as a flow rate, mass flow per unit time**.** A more useful parameter is the specific fuel consumption (SFC) the fuel flow rate per unit power output. It measures how efficiently an engine is using the fuel supplied to produce work (John B. Heywood, 1988).

Table.1. Test engine specifications.

| | |
|---|---|
| Fuel system | diesel with distributer pump |
| Bore × stroke | 76.50 mm × 86.40 mm |
| **Cylinders** | **4, Inline** |
| **Displacement** | **1588 cc** |
| Compression ratio | 23:1 |
| Injection plunger travel when engine piston is at TDC | 1 mm |

# 3. Results and Discussion

### *3.1. Extraction and biodiesel yield*

The machine extracts about 37.5% (v/w ratio) of oil from the sample seed (around 150 ml of oil from 400 grams of seed). If the residue from mechanical pressing was again continued to chemical extraction method, more oil had been expected from the sample; but this method was not applied to the residue after mechanical pressing. Usually, from castor up to 55% oil is expected if fully extracted. The biodiesel was synthesized using batch wise transesterification process. After washing two times with warm water ($50^0$C), the clear solution of biodiesel was measured. The biodiesel production yield is found to be 98 % v/v.

### *3.2. Characterization results*

Characterization was done to know the properties of the biodiesel produced whether it satisfies the ASTM standards for biodiesel prior to testing its performance in the existing diesel engines without doing any modification. The characterization results of the biodiesel produced from castor seed are shown in the table bellow.

Table 2. Characterization results of castor seed biodiesel.

| S.N | Property | Tests ASTM | Limit 6751-07b | Test Result | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $B_0$ | B5 | $B_{10}$ | $B_{20}$ | $B_{4O}$ | B80 | B100 |
| 1. | Density@$15^0$c,g/ml | D1298 | Report | 0.8526 | 0.8565 | 0.8581 | 0.8670 | 0.8837 | 0.9170 | 0.9345 |
| | Density@$20^0$c,g/ml | D1298 | Repot | 0.8482 | 0.8527 | 0.8547 | 0.8636 | 0.8804 | 0.9137 | 0.9312 |
| 2. | Distillation% V | D86 | - | - | - | - | - | - | - | - |
| | IBP$^0$C | | - | 172 | 164 | 163 | 162 | 166 | <123 | <113 |
| | 10%,recovered | | - | 204 | 200 | 201 | 218 | 217 | 246 | 296 |
| | 40%recovered | | - | 267 | 267 | 273.5 | 285.5 | 300 | 315 | 322.5 |
| | 50%recovered | | - | 281.5 | 282.5 | 290.5 | 304 | 316 | 321.5 | 326.5 |
| | 90%recovered | | Max360$^0$C | 351 | 352 | 355 | 354 | 341.5 | 327.5 | 336.5 |
| | 95%recovered | | | 367.5 | 366.5 | 364 | 363 | 341.5 | 330.5 | 366.5 |
| | FBP | | Max 390 | 380.5 | 370.5 | 368.5 | 365 | 341.5 | 330.5 | 366.5 |
| 3. | Flash point ($^0$C) | D93 | 100 Min | 68 | 68 | 69 | 69 | 69 | 86 | 152 |
| 4. | Copper strip corrosion 3hrs@100$^0$C | D130 | Max 3 | 1a | 1a | 1a | 1a | 1a | 1a | 1a |
| 5. | Cloud point, $^0$C | D2500 | Repot | -1 | 0 | 0 | 0 | +2 | 0 | <-12 |
| 6. | Kinematicviscosity@ 40$^0$C,mm$^2$/s | D445 | 1.9__ 6 | 3.04 | 3.1 | 3. 37 | 3.97 | 5.64 | 12.36 | 18.34 |
| 7. | Cetane Index | D976 | Min 47.0 | 49.44 | 48.4 | 49.15 | 49.52 | 45.3 | 37.7 | 34.6 |
| 8. | ASTM color | D1500 | Max =3 | 2 | 2 | 2 | 2 | 2 | 1.5 | <0.5 |
| 9. | Water and segment,%V | D2709 | Max 0.03 | <0.025 | <0.025 | <0.025 | <0.025 | <0.025 | <0.025 | <0.025 |
| 10 | Totalacidity,mgKOH/ g | D974 | Max 0.5 | 0.0076 | 0.0156 | 0.0259 | 0.0384 | 0.0656 | 0.1015 | 0.1215 |
| 11 | Ash content, mass% | D482 | Max 0.01 | 0.0065 | 0.0073 | 0.0078 | 0.0169 | 0.041 | 0.0704 | 0.0728 |
| 12 | Higher Heating value ,MJ/Kg | __ | Report | 45.33 | 45.053 | 44.776 | 44.222 | 43.114 | 40.898 | 39.79 |

The specific gravity and kinematic viscosity of the blends increase as the percentage of biodiesel increases as shown in the table above.

Kinematic viscosity is the most important physical characteristic to decide whether it is possible to test the fuel on an engine or not. From the table of results above, it is possible to see that the kinematic viscosity of B80 and B100 are out of the standard given by ASTM to use directly on CI engines. Hence, B80 and B100 are out of specifications and their performance on CI engines cannot be measured. This is because as the viscosity is higher, it will clog fuel filters; it will not be sprayed properly by the injector nozzles; and hence, poor atomization and poor spray pattern will affect combustion. Moreover, the poor combustion of the fuel will produce large amount of carbon deposit that will be a cause for valve face and valve seat burn, piston ring stuck and contamination of lubricating oil. In the distillation characterization process, the initial boiling point (IBP), the final boiling point (FBP), and the boiling temperatures corresponding to 10% increments of the volume of fuel distilled was recorded. Finally each recorded temperatures were corrected to 760 mmHg pressure.

Copper Corrosion test was done to assess the relative degree of corrosivity of petroleum products due to active sulfur compounds. Results are rated by comparing the stains on a copper strip to a color-match scale from 1-4. The ASTM D6751 limit for copper corrosion is number 3. All of the biodiesel passed ASTM specifications with 1a. Knowledge of the water and sediment content of petroleum products is important in the refining, purchase, sale, and transfer of products. The amount of water as determined is used to correct the volume involved in the custody transfer of petroleum products and bituminous materials. This test is a measure of cleanliness of the fuel. For B100 it is particularly important because water can react with the esters, making free fatty acids, and can support microbial growth in storage tanks. Water is usually kept out of the production process by removing it from the feedstocks. However, some water may be formed during the process by the reaction of the sodium or potassium hydroxide catalyst with alcohol. If free fatty acids are present, water will be formed when they react to either biodiesel or soap.

Finally, water is deliberately added during the washing process to remove contaminants from the biodiesel. This washing process should be followed by a drying process to ensure the final product will meet ASTM standard. Sediments may plug fuel filters and may contribute to the formation of deposits on fuel injectors and other engine damage. Sediment levels in biodiesel may increase over time as the fuel degrades during extended storage.

The water and sediment level of all the samples tested in this research is found to be below 0.025 % volume which is in the limit set by ASTM standards.

Cetane number index (CNI) of petrodiesel is calculated using corrected mid boiling point value from ASTM D86 and density at 15 $^0$C, from ASTM D 976 by using the following relation.

$$CNI = 454.74 - 1641.461D + 774.74D^2 - 0.554B + 97.803(LogB)^2 \quad (1)$$

Where, D = Density at 15 $^0$C, g/ml

B = Corrected mid boiling point $^0$C,

The cetane index values for the blends B5, B10, and B20 are within the standards; B40 is a little bit less than the standard whereas the others are very much below the standard set.

As the cetane number of the fuel is getting lower, its auto-ignition quality will be poorer resulting in longer ignition delay period which makes the engine susceptible to diesel knocks.

The flash point temperature is one measure of the tendency of the test specimen to form a flammable mixture with air under controlled laboratory conditions. It is only one of a number of properties which must be considered in assessing the overall flammability hazard of a material.

Flash point is used in shipping and safety regulations to define flammable and combustible materials. One should consult the particular regulation involved for precise definitions of these classifications. The U.S. Department of Transportation (DOT) and U.S. Department of Labor have established that liquids with a flash point under 37.8°C (100°F) are flammable.

The test methods should be used to measure and describe the properties of materials, products, or assemblies in response to heat and an ignition source under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of these test methods may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use (www.astm.org/Standards/D93.htm,2011). From the result table above, it is observed that biodiesel has a higher flash point – the temperature at which a fuel will catch fire – because biodiesel has a high number of FAMEs which are generally not volatile. Thus, biodiesel is safer to handle at higher temperatures than diesel.

The ASTM Color Scale is widely utilized for the grading of petroleum products such as lubricating oils, heating oils and diesel fuel oils. Mineral oils are constantly checked for colour during processing in order to establish when they have been refined to the required grade. Colour is also used as a means of confirming that the correct oil or fuel is being used for its intended use and that no contamination or degradation of quality has occurred. The ASTM color results of the fuels in this research are well within the standards.

The acid number is used as a guide in the quality control of lubricating oil formulations. It is also sometimes used as a measure of lubricating degradation in service. Acid numbers higher than 0.80 have been associated with fuel system deposits and reduce life of fuel pumps and filters. Acid number determination is an important test to assess the quality of a particular biodiesel. It can indicate the degree of hydrolysis of the methyl ester, a particularly important aspect when considering storage and transportation as large quantities of free fatty acids can cause corrosion in tanks (Wang, H, 2008). The acidity of the biodiesel produced in this research is in the limit set by ASTM. Hence, it will not create any corrosion on the fuel system components.

Knowledge of the amount of ash forming materials present in a product can provide information as to whether the product is suitable for use in a given application or not. Ash can result from oil or water soluble metallic compounds or from solids such as dirt and rust. For biodiesel, this test is an important indicator of the quantity of residual metals in the fuel that came from the catalyst used in the transesterification process. Producers that use a base catalyzed process may wish to run this test regularly. Many of these spent sodium or potassium salts have low melting temperatures and may cause engine damage in combustion chambers. High concentrations of metals contained in the fuel can cause injector tip plugging, combustion deposits and injection system wear. The ash content test result of the fuels in this research shows that B20, B40, B80 and B100 are above the standards.

***The Saponification Number (SN) and the Iodine Value (IV)***

The SN and IV of the oils is determined and the result is shown in the table 3 bellow

Table 3. Saponification and iodine Values

| Sample fuel | SN (mg of KOH /gm of oil) | IV (g of Iodine / 100 g of oil) |
|---|---|---|
| B100 | 202.71 | 88.72 |

The heating values are calculated by using their SN and IV obtained from simple chemical analyses using empirical relation;

$$HHV = 49.43 - 0.041 (SV) - 0.015 (IV) \quad (2)$$

The heating value or heat of combustion or calorific value measures the energy content in a fuel. From an operational point of view, biodiesel has about 90% of the energy content of petroleum diesel, measured on a volumetric basis. Due to this fact, on average basis the use of biodiesel reduces the fuel economy and power by about 10% in comparison with petroleum diesel. The reason for this reduction stems mainly from the oxygen content of biodiesel, ensuing better combustion process, and improved lubricity, which partly compensate for the impact of the lower energy content. Biodiesel is an oxygenated compound. Oxygenates are just pre used hydrocarbons having a structure that provides a reasonable antiknock value. Also, as they contain oxygen, fuel combustion is more efficient, reducing hydrocarbons in exhaust gases. The only disadvantage is that oxygenated fuel has less energy content. For the same efficiency and power output, more fuel has to be burned (Shay, E.G , 1993, Demirbas, A, 2006).

### *3.3. Results of the performance test*

After the fuel properties of the net biodiesel (B100), the petrodiesel (B0) and their blends (B5, B10, B20, B40, and B80) are studied, those blends which satisfy the ASTM standards are identified to test their performance characteristics in CI engines. The blends that satisfy the ASTM standards in this research work are B5, B10, B20 and B40. Therefore their performance characteristics (Torque, power and fuel consumption) are compared with that of the petrodiesel (B0) as follows.

#### *3.3.1. Torque Vs Speed*

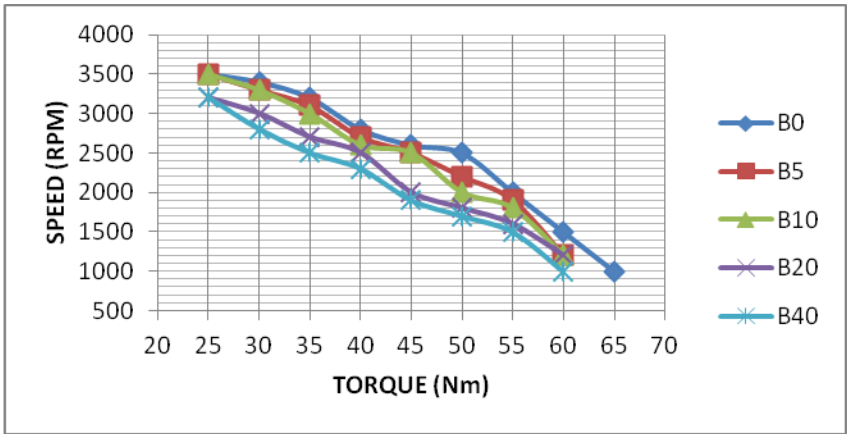


*Figure 1: Torque Vs Speed characteristic curves.*

From figure 1 above, torque performance with fuel blends, one can say that the trend of the parameter versus speed is almost similar to neat diesel fuel. Particularly at high engine speed ranges for all types of fuels the resistance to flow (flow losses) are very high and short opening periods of the valves. This results in reduced cylinder filling and hence reduced volumetric efficiency, engine power and engine torque. It is also clear to see that at a particular speed values the torque output decreases as the percentage of biodiesel increases in the blends. This is may be due to the lowering of the heating value of the fuels as the percentage of the biodiesel in the blends is increasing.

#### *3.3.2Torque vs Power*

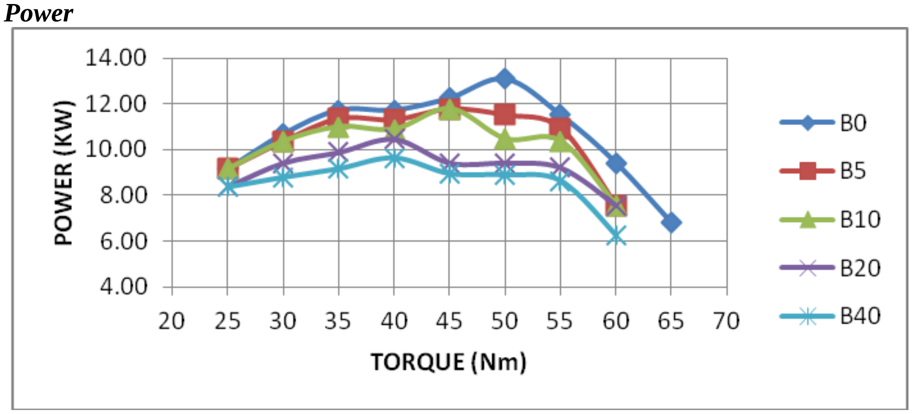


*Figure 2. Torque Vs Power characteristic curves.*

From the above curves it is possible to say that the trend of the curves is almost similar. But the power output reduces as the percentage of the biodiesel increases in the blends due to the reduction in the heating values of the blends. At lower torque values the power output is reduced due to insufficient time for charging of the cylinders (reduction in the volumetric efficiency). At higher torque values the power output is also reduced due to increased time for heat losses.

***3.3.3. Torque vs brake specific fuel consumption (bsfc)***

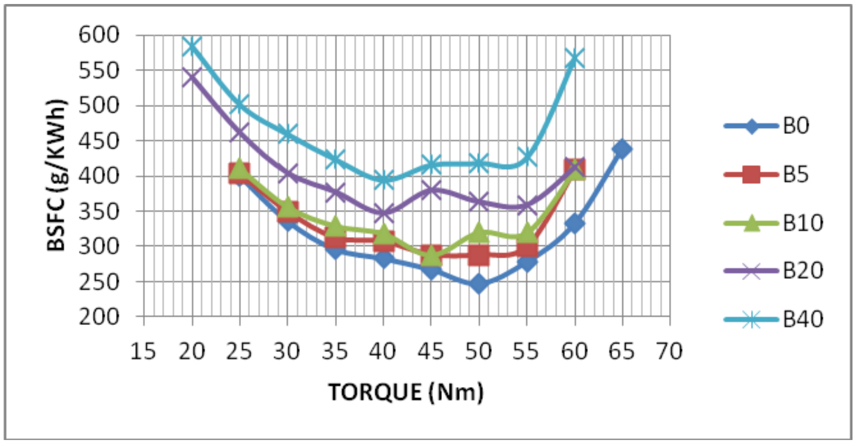


*Figure 3. Torque Vs brake specific fuel consumption characteristic curves.*

The specific fuel consumption, SFC, is a measure of how efficiently the fuel supplied to the engine is used to produce power. Clearly a low value for SFC is desirable since for a given power level the lesser the fuel consumed the better it is.

Brake specific fuel consumption (BSFC) defines the amount of fuel needed by the engine to produce one kilo watt hour (1 KWh) of useful energy output. Normally, lower engine speeds produce a higher BSFC because of increased time for the heat transfer from the working fluid to the cylinder walls. Also higher engine speeds produce a high BSFC because of rising friction losses in the engine. Higher friction losses reduce brake torque, which increases BSFC. The lower BSFC value of diesel is attributed to the lower density and weaker molecule bonds leading to a lower flash point. Consequently, petrodiesel is burnt faster than biodiesel giving higher amount of torque within the same time. Further, the lower calorific value for biodiesel fuels resulted in consuming more fuel to produce same torque developed by normal diesel. This results in increase in engine specific fuel consumption (Lapuerta, M., et al, 2008).

From figure 3 above , it is possible to see that the trend of the curves for all blends is similar and comparable with that of the petro diesel. But the BSFC increases as the percentage of the biodiesel increase in the blends.This may be is due to that biodiesel is an oxygenated fuel. The higher fuel viscosity may also reduce the quality of fuel atomization, and could result in higher gas emission and fuel consumption. However, this increase was partially compensated by the higher density of biodiesel in the volumetric injection system, and thus, differences in volumetric consumption between diesel and biodiesel became smaller. As long as diesel fuels are delivered by volume, the final sale price of biodiesel should be proportionally lower.

## 4. Conclusions

The main aspiration of the research was to produce biodiesel from castor seed and compare its performance characteristics with that of petrodiesel in the existing four stroke cycle diesel engine without making any modifications to it. The results from the research are illustrated as follows.

- Castor plant can grow in all types of land, weather conditions and seasons in Ethiopia. Moreover castor plant is not attacked by wild or domestic animals. Hence, farmers can grow it on land which is not used for cultivation of crops, and around their farms as a fence to protect their crops from animals attack. This will become an additional income for the farmers and will be an opportunity for the country to produce diesel fuel above the earth’s surface (biodiesel), which is beneficiary in many perspectives as local job creation, petroleum import substitution, fuel price stabilization, and stimulating enormous growth of rural incomes and ultimate national economic growth. In addition, planting perennial oil crops provide great ecological advantages in terms of erosion control and wasteland recovery; Vegetable oils have potential for making marginal land productive by their property of nitrogen fixation in the soil.
- Transesterification has been found to be an effective technique to prevent some long-term problems associated with utilization of vegetable oils such as fuel filter plugging, injector coking, formation of carbon deposits in combustion chamber, ring sticking, and contamination of lubricating oils.
- All the tests from characterization of biodiesel demonstrated that, almost all the important properties of biodiesel (except for B100 & B80) are in very close agreement with the mineral diesel, making it a potential candidate for the application in CI engines.
- From the experiment it is seen that castor seed has higher biodiesel yield and the characterization results witness that biodiesel from castor seed can be blended with petrodiesel in order to minimize the problems that can arise from its higher viscosity while using the neat biodiesel in unmodified diesel engines. Hence, the research shows a good bright future, that it is possible to produce an everlasting and safer fuel above the earth’s surface which can potentially substitute petrodiesel.

- The performance test results depict the tested blends (B5, B10, B20, and B40) perform almost similar when compared with the performance of petrodiesel. The torque and power performances get reduced and fuel consumption increase as the percentage of biodiesel in the blends increase. This is because of the fact that biodiesels are oxygenated fuels and hence has less energy content compared to petrodiesel. But this little reduction in performance can be compensated with lots of its advantages like its usage in unmodified engine, better lubricity, renewability, degradability, very less contribution to global warming, and its provision of great ecological advantages in terms of erosion control and wasteland recovery.
- From the performance characteristics it is seen that diesel engine can perform satisfactorily on biodiesel blends without any engine hardware modifications.
- From the performance result it is seen that out of the blends, B5 is most nearer to petrodiesel performances and hence it is possible to start driving diesel engine vehicles with 5% biodiesel and 95% petrodiesel blend. But small generators and water pump engines (because the load imposed on them is not that much bigger) can be fueled with B20, a 20% biodiesel and 80% petrodiesel blend; which brings a great cost reduction especially for farmers (because biodiesel is locally produced).
- Nowadays, Ethiopia is producing alcohol (ethanol), the most important feed stock for the production of biodiesel, through its sugar factories, which again reduces the cost for importing this feed stock. This will encourage the opportunity to produce biodiesel in the country.

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