The Journal of **Macro**Trends in Energy and Sustainability

MACROJOURNALS

Biodiesel Production from False Flax (Camelina Sativa) Oil and Its Blends with Diesel Fuel

Şafak Yıldızhan and Hasan Serin
Department of Automotive Engineering, Cukurova University, Adana, 01330, Turkey

Abstract

False flax (Camelina Sativa) has a potential of being feedstock for biodiesel production because of low production cost in some climates. In this study biodiesel production from false flax (Camelina Sativa), oil properties and fuel properties of false flax has been studied. Methyl esters were produced by transesterification of false flax oil (FFME) with methanol in the presence of a catalyst (NaOH). The fuel properties such as cold filter plugging point (CFPP), kinematic viscosity, cetane number, flash point, density, and heating value were determined and discussed in light of American (ASTM D6751) and European (EN 14214) biodiesel standards. In addition to fuel properties, oil properties of false flax have also been evaluated. False flax has a low cold filter plugging point value of -10 oC which is very close to standard diesel fuel. The cold flow properties of FFME show its operational feasibility during the cold weather conditions. Consequently, False Flax oil, might be a feasible raw material for the biodiesel production.

Keywords: *Biodiesel, False Flax Oil, Camelina Sativa, Transesterification, Fuel*

1. Introduction

Biodiesel, renewable clean bio-energy, can be produced from vegetable oils, animal fats or used cooking oil which is reacted with alcohol to form esters (biodiesel) and glycerol [1-2].

Researchers are looking forward to new raw materials, especially non-edible materials for biodiesel production [3, 4, 5, 6]. Many vegetable oils such as pomace oil [7], soybean oil [8], castor oil [1], tobacco seed oil [9], safflower seed oil [10], terebinth oil [11], tea seed oil [2] and karanja oil [12] etc. have been used for producing biodiesel fuel.

Camelina sativa is a new crop with a variety of uses. It is relatively easy to grow with low input costs. It is a spring annual broadleaf oilseed herb of the Brassicaceae family that grows well in moderate climates. Its meal valuable as animal feed, and its oil has important nutritional components (alpha linolenic acid and gamma-tocopherol). Camelina seed contains 30-40% oil that could be used as a fuel [13].

The aim of this experimental work is to investigate Camelina Sativa (false flax) as an alternative feedstock for the production of a biodiesel fuel. Biodiesel was prepared from the false flax by transesterification of the crude oil with methanol in the presence of NaOH as a catalyst. Properties of false flax oil and biodiesel produced by transesterification were within the limits of ASTM and EN standards.

2. Experimental

The experimental study was conducted in Petroleum Research and Automotive Engineering Laboratories of the Department of Automotive Engineering at Çukurova University. False Flax oil is used as a raw material for biodiesel production. The samples of false flax were supplied from a local oil company, Gaziantep, Turkey.

False flax oil methyl ester (FFME) was produced via the transesterification method. In this reaction, methyl alcohol and sodium hydroxide (NaOH) were used as reactant and catalyst. The chemicals (methanol and sodium hydroxide) which were used during the experiments were purchased from Merck and methanol was purified prior to use. In order to determine best production condition, transesterification reaction was carried out in a spherical glass reactor equipped with reflux condenser, stirrer and thermometer. In the reaction, molar ratio of alcohol to oil was 6:1. The reaction were performed with following conditions, methanol 20 wt %, sodium hydroxide 0.5 wt %, temperature 60 ^{o}C, time 90 minutes. Methanol and sodium hydroxide were mixed in order to obtain sodium methoxide. Then, sodium methoxide and false flax oil were mixed in the reactor. The mixture was heated up to 60 ^{o}C and kept at this temperature for 90 minutes by stirring. After the reaction period, the crude methyl ester was waited at separating funnel for 8 hours. And then, crude glycerin was separated from methyl ester. Finally, the crude methyl ester was washed by warm water until the washed water became clear and dried at 105 ^{o}C for 1 hour. Finally washed and dried methyl ester was passed through a filter. At the end of the transesterification reaction 97% conversion of oil was obtained.

Instruments used for analyzing the product; Zeltex ZX 440 NIR petroleum analyzer with an accuracy of ±0.5 for determining cetane number; Tanaka AFP-102 for cold filter plugging point; Tanaka AKV-202 Auto Kinematic Viscosity test for determining the viscosity; Kyoto electronics DA-130 for density measurement, Tanaka flash point control unit FC-7 for flash point determination and IKA Werke C2000 bomb calorimeter for determination of heating value.

In this study, two mixtures of false flax biodiesel (FFME) - diesel fuel (D) were evaluated as test fuels. These fuels are 10% FFME-90%D, 20% FFME-80%D which are called B10, B20, respectively. Test fuels were mixed on volume basis. After the preparation of test fuel blends, fuel properties of blends were measured. Results were compared with diesel fuel and B100. All measurements were repeated three times and averages of tests were stated. Table 1 shows the fuel properties and measurement devices.

Table 1. Fuel properties and measurement devices

Property	Device	Accuracy
Cetane Number	Zeltex ZX440	3%
Lower Heating Value (LHV)	IKA-Werke C2000 Bomb Calorimeter	0.001 K
Density	Kyoto Electronics DA-130	±0.001 g/cm^3
Viscosity	TANAKA AKV-202 Auto Kinematic Viscosity	-
Flash Point	Tanaka Automated Pensky-Martens Closed Cup Flash Point Tester APM-7	-
CFPP	Tanaka AFP-102	-

3. Results and Discussion

3.1. Oil Properties

In general, false flax oil contains unsaturated fatty acids which are important advantages for the fuel properties of biodiesel such as lower pour point., Table 2 represents the oil specifications of false flax which is compared with Yingqiang Sun, 2014 [14]. In some case, pure oil usage in compression ignition engines may be possible according to oil specification however false flax oil is not recommended for pure usage due to its high viscosity which can cause injection system failure [2].

Table 2. Oil Specifications of Camelina Sativa Seed (false flax) oil

Properties	Camelina Sativa Seed (False Flax) oil	Camelina oil (Yingqiang Sun,2014)
Density, kg/m^3	888	0.91–0.92
Cetane Number	42.27	35.16–36.25
CFPP, °C	-10	-
Lower heating value, MJ/kg	38.72	39.10
Kinematic viscosity, mm^2/s	29.5	14.05–15.10
Flash point °C	92.5	-

3.2. Fuel Properties

Fuel properties of false flax oil methyl ester and its blends with diesel fuel were shown in Table 3. The density of FFME was found higher than that of diesel fuel. Due to the higher density of FFME in accordance with the diesel fuel, blending with FFME was caused an increase in the density values. Any increase in the percentage of the FFME caused a rise in the blend density. Density values of all blends meet European Biodiesel Standard.

Table 3. Fuel properties of test fuels

Properties	Diesel fuel	EN590	B10 (%)	B20 (%)	B100 (%)	ASTM D 6751	EN 14214
Density, kg/m^3	837	820−845	839	844	886	-	860 - 900
Cetane Number	59.47	Min 51	55.10	54.77	51	Min 47	Min 51
CFPP, °C	-11	-	-11	-11	-10	-	Summer <4,0 Winter< -1,0
Lower heating value, kJ/kg	45856	-	43181	41436	39048	-	-
Kinematic viscosity, mm^2/s	2,76	2.0−4.5	2, 82	2,97	4,38	1.9–6.0	3,5 – 5,0
Flash point °C	79,5	Min 55	84,8	91,3	>140	Min 93	Min 120

The heating value of FFME is 14,8% lower than that of diesel fuel. The heating values of FFME and diesel fuel were measured as 39048 and 45856 kJ/kg, respectively. Generally cetane number is an indicator of the ignition quality of a diesel fuel. If the cetane number is too high, combustion can occur before the fuel and air are properly mixed, which results incomplete combustion and smoke. If a cetane number is too low, incomplete combustion occurs [15]. Cetane number of FFME was measured as 51 which satisfy the American and European Biodiesel Standards. The temperature at which is the lowest temperature of the standardized volume of fuel can pass through a standardized filter is determined by cold filter plugging point (CFPP). Also CFPP is a significant property which is relative with pour point. Methyl ester derived from false flax oil has a CFPP of -10 ^oC which is considerably low compared with other biodiesel fuels such as palm oil biodiesel, cotton seed oil biodiesel, peanut oil biodiesel. Viscosity, which is a measure of resistance to flow of a liquid due to internal friction of one part of a fluid moving over another, affects the atomization of a fuel upon injection into the combustion chamber and thereby, ultimately, the formation of engine deposits. The general rule is; the higher the viscosity, the greater the tendency of the fuel to cause such problem [15]. Analysis revealed that, FFME has higher viscosity value than diesel fuel (4.38 and 2.76 mm^2/s respectively), however; there is no problem to comply with standards. Viscosity values of blends showed an increasing trend with the increased FFME rates in the blends due to its high viscosity. The flash point is the temperature at which the fuel will give off enough vapor to produce a flammable mixture [2]. This is important information for the safe transportation, storage of the fuel. The experiments showed that FFME has flash point of over 140 ^{o}C which is acceptable according to European Biodiesel Standards.

4. Conclusions

False flax (Camelina Sativa*)* oil was used as a raw material for the biodiesel production via the alkali-catalyzed transesterification. Fuel properties of FFME, diesel fuel and blends such as density, flash point, heating value, cetane number, cold filter plugging point and viscosity were determined. The significant properties of biodiesel derived from false flax oil are the low CFPP of approximately -10 ^{o}C and high flash point of higher than 140 ^{o}C. FFME is a feasible alternative for petro diesel and it is possible to use pure FFME in compression ignition engines without any major modification.

Acknowledgements

The authors would like to thank the Cukurova University Scientific Research Project Coordination (FBA-2015-3897) for financial support to this project.

References

[1] Ozcanli, M., H. Serin, K. Aydin and S. Serin (2011). Ricinus Communis (Castor Oil) methyl ester as a natural additive for biodiesel fuels. Energy Education Science and Technology Part A: Energy Science and Research 27(2):331-336.

[2] Serin H., M. Ozcanli, M.K. Gokce., G. Tuccar (2013). Biodiesel Production From Tea Seed (Camellia Sinensis) Oil and its Blends With Diesel Fuel. International Journal of Green Energy, 10:4, 370-377

[3] Anwar, F., U. Rashid, M. Ashraf and M. Nadeem (2010). Okra (Hibiscus esculentus) seed oil for biodiesel production. Applied Energy 87:779-785.

[4] Balusamy, T. and R. Marappan (2010). Effect of injection time and injection pressure on ci engine fuelled with methyl ester of thevetia peruviana seed oil. International Journal of Green Energy 7:397-409.

[5] Saribiyik, O.Y., M. Ozcanli, H. Serin, S. Serin and K. Aydin (2010). Biodiesel production from ricinus communis oil and its blends with soybean biodiesel. Strojniški vestnik - Journal of Mechanical Engineering 56:811-816

[6] Altun, S. (2011). Fuel properties of biodiesels produced from different feed stocks. Energy Educ. Sci. Technol. Part A 26:165-174.

[7] Caynak, S., M. Gürü, A. Biçer, A. Keskin and Y. Içingür (2009). Biodiesel production from pomace oil and improvement of its properties with synthetic manganese additive. Fuel 88:534-538.

[8] Canakci, M. and J.H. Van Gerpen (2003). Compression of engine performance and emission for petroleum diesel fuel, yellow grease biodiesel, and soybean oil biodiesel. Trans. ASAE 46:937–44.

[9] Usta, N. (2005). Use of tobacco seed oil methyl ester in a turbocharged indirect injection diesel engine. Biomass and Bioenergy 28:77-86

[10] Hamamci, C., A. Saydut, Y. Tonbul, C. Kaya and A.B. Kafadar (2011). Biodiesel production via transesterification from safflower (Carthamus tinctorius L.) seed oil. Energy Sources, Part A, 33:512–520

[11] Ozcanli, M., A. Keskin and K. Aydın (2011). Biodiesel Production from Terebinth (Pistacia Terebinthus) Oil and Its Usage in Diesel Engine. International Journal of Green Energy 8:518-528.

[12] Srivastava, P.K. and M. Verma (2008). Methyl ester of karanja oil as an alternative renewable source energy. Fuel 87:1673-1677.

[13] Stanisław W. Kruczynski (2012). Performance and emission of CI engine fuelled with camelina sativa oil. Energy Conversion and Management 65 (2013) 1–6

[14] Yingqiang, S. , Harvind, K. R., Tapaswy, M. Sundaravadivelnathan, P., Prafulla, D. P., Changzhu, L. , Lijuan, J. , Shuguang, D. (2014). A comparative study of direct transesterification of camelina oil under supercritical methanol, ethanol and 1-butanol conditions. Fuel 135 (2014) 530–53

[15] Gerpen, J.V., B. Shanks, R. Pruszko, D. Clements and G. Knothe (2004). Biodiesel Analytic Methods, National Renewable Energy Laboratory, Colorado.