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PRODUCTION AND CHARACTERIZATION OF BIODIESEL-DIESEL BLENDS FROM *Terminalia Catappa* SEED OIL

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ABSTRACT

This study investigates the opportunity of using *Terminalia catappa* seed oil as a renewable and alternative fuel source. The oil was extracted using mechanical pressing and solvent extraction method and the percentage oil yield was 56.30%. The oil was degummed using 4% Citric acid and the physiochemical properties of the oil were carried out using standard methods. The acid value, viscosity, moisture content and ash content were found to be 3.82 mgKOH/g, 46.0 mm^2/s, 2.40 % and 0.65 %w/w respectively. Biodiesel was produce via a two stage esterification and transesterification. Fuel properties of biodiesel produced were carried out using American Standard for Testing and Material (ASTM) methods Biodiesel-diesel blend of B6, B10, and B20 were prepared and the influence of blending on fuel properties was determined. Result showed that biodiesel and blend of B6-B20 satisfy ASTM D6751 and ASTM D7467 standards, respectively.

Keywords: biodiesel, transesterication, blend, fossil diesel, *Terminalia catappa* oil

INTRODUCTION

Terminalia catappa is a tropical tree which belongs to the *combretaceae* family. *Terminalia catappa* tree is grown commonly as a shade tree in towns, villages and cities, the tree is found in most residential and public quarters in Nigeria (Adewuyi *et al.,* 2011). The oil yield of *T. catappa* has been reported in the literature to be 55.05 g/100g (Oderinde 1998). The utilization of *Terminalia catappa* a source of non-edible vegetable oil as a raw material for the production of biodiesel-diesel blend in Nigeria will not affect food security. It will reduce the production cost and give rise to availability of alternative fuel that is environmentally friendly and affordable.

Biodiesel‘s physical properties are similar to those of petroleum diesel, but the biodiesel significantly reduces greenhouse gas emissions and toxic air pollutants (Dallatu, 2015). Biodiesel can be used in its pure state or blended with petroleum based diesel fuel. Biodiesel can be blended in many different ratios, these includes; B100 (pure biodiesel), B20 (20% biodiesel, 80% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel), and B2 (2% biodiesel, 98% petroleum diesel) (Ali *et al.,* 2013). The most common biodiesel blend is B20, which qualifies for fleet compliance under the Energy Policy Act (EPAct) of 1992. The implication is that majority of the diesel engines are design to accommodate blends of biodiesel to diesel ratio from B0 to B20. Therefore, the current mandates regarding the use of biodiesel around the world are mostly based on a biodiesel–diesel blend up to 20% biodiesel. The B20 blend provides a superior diesel fuel with a higher cetane rating, superior lubricity and significant emission reductions, cold weather can cloud and even gel any diesel fuel, including biodiesel, but using a 20 percent biodiesel blend will cause an increase of the cold flow properties (cold filter plugging point, cloud point, pour point) by approximately 1 °C (Dallatu, 2015). Biodiesel blends have powered thousands of vehicles, in the United States and is used both as a 5 % blend in France up to 100% neat fuel in Austria and Germany (National Biodiesel Board, 1996). The use of biodiesel blends could reduce CO_2 accumulated in the atmosphere by 78% due to CO_2 recycling by growing plants. In addition, other harmful substances such as particulate matter (PM), hydrocarbons (HC), and carbon monoxide (CO) are considerably reduced (U.S. Department of Energy, 2004).

Several studies have reported the use of *Terminalia catappa* (Almond) seed oil for biodiesel production (Dos Santos *et al*., 2008; Atapour and Kariminia 2011; Adewuyi *et al*., 2011; Giwa and Ogunbona, 2014). However none of these studies explore the opportunity of using *Terminalia catappa* biodiesel as a blended fuel with fossil diesel, hence the present study. Thus, the present study investigates the effect of blending biodiesel from *Terminalia catappa* oil with fossil diesel

The motivation of this study lies in the rising demand for alternative source of energy due to the increasing world population, accelerated rate of industrial and domestic activities that require constant supply of energy and the current mandate regarding the use of biodiesel-diesel blend up to B20 around the world.

MATERIALS AND METHOD

Materials

Fully matured almond fruits - *Terminalia catappa* - were collected within the premises of Ahmadu Bello University main Campus Zaria, Kaduna State, Nigeria. The edible portion (flesh) was manually removed, leaving the stony shell containing the seed. The stony shell was carefully cracked to remove the groundnut-like seed. 2 kg of almond seeds were gathered and sun-dried for two weeks before being milled using a domestic blender. The resulting powder was preserved in airtight sample bottles under cool condition in preparation for oil extraction (Giwa and Ogunbona, 2014).

Oil Extraction

The Oil was extract by a mechanical pressing machine at the National Research Institute for Chemical Technology (NARICT), Zaria. The expelled oil was filtered using a Muslin sieve into a beaker. The pulp was then dissolved in cyclohexane to extract the remaining oil. The pulp was filtered out from the solution. The remaining oil and cyclohexane are separated by means of distillation.

The percentage oil yield was then calculated thus:

$$\%\ Oil\ yield = \frac{Weight\ of\ oil\ (g)}{Weight\ of\ ground\ seed\ (g)}\ X\ 100$$

Degumming of oil

1000g of the oil was preheated to 80^{o}C, water solution of citric acid (4%) was then added in amount of 10% (by volume of oil). The mixture was stirred for 20 minutes. The oil/acid mixture was transferred to a holding vessel to settle for 60 minutes after which the degummed oil was separated from its by-products.

Physiochemical properties of the oil

The physiochemical properties of the oil were conducted in accordance with standard test method described in the AOCS (1998). The properties are density, acid value, kinematic viscosity, moisture content, iodine value, saponification value and ash content

Determination of Fatty Acid Composition

The gas chromatographic analysis of *Terminalia catappa* seed oil was made using GC-MS QP2010 PLUS SHIMADZU, JAPAN. The gas chromatograph was equipped with a capillary column of dimension 30m x 250µm x 0.25µm packed with non-polar HP-5. The column temperature was programmed initially at 100 ºC for 20 min, and then increased to 180ºC at the rate of 10ºC/min, for 10 min and then increased to 290 ºC. The inlet temperature was set at 300ºC. Acquisition was carried out using SCAN mode. The sample was first methylated by dissolving 0.125g of the oil in 5.0cm^3 of n-hexane. The methylated sample was diluted in hexane and 1µl of this solution was injected into the column at a temperature of 230 ºC, and a detector temperature of 240 ºC, while the nitrogen gas was maintained at 5.5Psi. The injection was performed in split mode with a split ratio of 50:1. Helium was used as the carrier gas at a flow rate of 0.8cm^3/m. The fatty acids were eluted as peaks. The identification of peaks was done by comparison of their retention times and mass spectra with NIST05 Library.

Esterification procedure

The % FFA the oil (Table 1) is higher than the value (<1%) required for direct transestercation reaction (Balat and Balat, 2010). hence necessitated the production of biodiesel by two stage methods; first by esterification, followed by transesterification. Acid esterification was conducted according to Van Gerpen *et al*. (2004). A mixture of 2.25 g methanol and 0.05 g conc. sulphuric acid was added for each gram of free fatty acid in the oil and warmed for 15 minutes on a hot plate. This mixture was then transferred slowly into the 250 cm^3 conical flask containing the oils followed by the addition of methanol (20.0g) and stirred (800 rpm) for 1 hour at 60^{o}C to esterify. At the end of the reaction, the resulting mixture was transferred into a holding vessel, the mixture was allowed to stand for 1 hour and a two phase solution was obtain in which methanol-water mixture is above and esterified oil is below. Further, the FFA was determined again in order to ensure it was less than 1.0% before base transesterification of the oil.

Transesterification

The method of laboratory scale biodiesel production employed by Meher *et al.,* (2006) was adopted. Exactly 20g of methanol was poured into a plastic container. 1g of the catalyst (NaOH) was carefully added to the plastic container and secured tightly. The container was placed on a shaker for about 5 minutes until the NaOH completely dissolved in the methanol, forming sodium methoxide. 100g of *Terminalia catappa* seed oil pre heated to 60^{o}C was poured into an electric blender. The prepared sodium methoxide from the plastic container was carefully poured into the blender. The blender was secured tightly, switch on at full agitation speed and the agitation was maintain for 30 minutes. The resulting product was poured into a separating funnel and allows to stand. The glycerine was tap off, leaving the biodiesel in the separating funnel. The biodiesel was washed with warm distilled water to remove traces amount of catalyst and glycerol in the methyl ester.

The percentage yield of biodiesel (fatty acid methyl ester) was calculated as:

$$Yield\ = \frac{Weight\ of\ biodiesel\ produce}{Weight\ of\ oil\ used}\ X\ 100$$

Biodiesel fuel characterization

Biodiesel properties of *Terminalia catappa* biodiesel (TCB) were determined according to ASTM test methods (ASTM D6751). The following properties were measured experimentally: acid value (ASTM D664), density (ASTM D5002), kinematic viscosity (ASTM D445), iodine value, pour point (D5949), cloud point (ASTM D2500), flash point (ASTM D93), cetane number (ASTM D613), oxidative stability

(EN14112), water and sediment (ASTM D2709), heating value (ASTM D4809) and ash content (ASTM D874).

Biodiesel blending

Biodiesel-diesel blends were prepared by mixing biodiesel with fossil diesel in ratios of 6:94 up to 20:80 of biodiesel to fossil diesel and labelled as B6 – B20 respectively. The ink tank method (Krishna, 2003) of petrol blending was adopted. Samples of *Terminalia catappa* oil methyl ester and fossil diesel were prepared as B6 (6%vol. TCB + 94%vol. fossil diesel), through mixing and blending using electrical magnetic stirrer. The mixtures were stirred continuously for 20 minutes and left for 30 minutes to reach equilibrium at room temperature before they were subjected to any test. The same procedure was followed to obtain blends of B10 and B20. The blends were centrifuged for homogeneity before proceeding with fuel analysis using ASTM standards.

RESULTS AND DISCUSSION

Oil content and Physiochemical properties of *Terminalia catappa* seed oil

The oil content of *Terminalia catappa* seed 56.30±1.50% obtained in this work is similar to the oil yield of *T. catappa* 55.05% reported by Oderinde (1998) and higher than the range (49.0 to 51.80 %) reported previously (Giwa and Ogunbona, 2014; Matos *et al*., 2009; Dos Santos *et al*., 2008) . This could be attributed to the extraction method employed in producing *Terminalia catappa* seed oil (TCSO), location of sample collection and soil type. The physiochemical properties of TCSO are presented in table 1.

Table 1: Physiochemical properties of *Terminalia Catappa* Seed oil

Properties	TCSO
Density gcm^{-3} at 15^{o}C	0. 881±0.02
Acid value mgkOH/g	3.82±0.13
FFA %	1.91±0.12
Viscosity at 40^{0}C mm^{2}/s	46.00± 1.00
Moisture content %	2.40±0.21
Iodine value gI_2/100g of oil	78.80±0.62
Saponification value mgkOH/g	192.57±0.65
Ash content% w/w	0.65±0.02

Note: values are mean ± standard deviation of triplicate determination

The acid value of TCSO was 3.82±0.13 mgKOH/g which was reduced to 0.54 mgKOH/g after pre-treatment (esterification process), and the density at 15 ^{o}C was 0.881 gcm^{-3}. The moisture content (2.40%) is lower than the rate of 4.13% reported for the seed oil by Matos *et al*. (2009) from *Brazzaville-Congo*, but it is comparable to that of 2.84% reported by Agetemor and Ukhun, (2006) in India. Environmental relative humidity associated with different climate could result in different moisture content of *Terminalia catappa* seed oil. The ash content obtained in the study (0.66% w/w) is lower than the value of 4.27% and 5.48% reported for the seed oil by Matos *et al*. (2009) and Etienne *et al*. (2015), respectively, this could be due to removal of phospholipids and other gummy materials during degumming process. The iodine value and saponification value of TCSO are 78.80 gI_2/100g and 192.57 mgKOH/g respectively, which were in close agreement with the values reported earlier for the seed oil (Dos Santos *et al.*, 2008; Adewuyi *et al*., 2011). The low moisture and ash content of the oil makes it more suitable for biodiesel production.

Fatty acid composition

The fatty acid profile of TCSO as shown in Table 2 comprises of myristic acid (C14:0), palmitic acid (C16:0), palmitoleic acid (C16:1), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2) and Arachidic acid (C20:0). The percentage composition of fatty acid obtain in this study was closely similar to those of other species of *Terminalia Catappa* previously reported by (Ng *et al*., 2015; Adewuyi *et al*., 2011; Dos Santos *et al.*, 2008) with the exception of sweat almond (Giwa and Ogunbona, 2014). The high percentage of saturated and monounsaturated fatty acid of *Terminalia Catappa* seed oil indicates high heat of combustion of the oil (Oseni *et al*., 2012). This property compliment other properties such as specific gravity, peroxide value, iodine value to make it a good potential for biodiesel production (Van Gerpen *et al*., 2004).

Table 2: Fatty acid profile of *Terminalia Catappa* seed oil

Fatty acids	% wt. of Seed Oil
Mynstic (14:0)	1.32
Palmitic (16:0)	37.50
Palmitoleic (16:1)	0.74
Stearic (18:0)	8.23
Oleic (18:1)	40.16
Linoleic (18;2)	9.95
Arachidic (20:0)	2.10
Saturated	49.15
Mono – unsaturated	40.92
Poly – unsaturated	9.95
Total unsaturated	50.85

Yield of *Terminalia catappa* methyl ester

The percentage conversion yield of TCSO to biodiesel using 1% w/w NaOH catalyst and 6:1 methanol to oil ratio at 30 minute reaction time was 92.68 ±0.31%, which is higher than 90.80% and 85.90% reported by Atapour and Kariminia (2011) and Giwa and Ogunbona (2014) respectively, for biodiesel from the same seed oil. This is due to removal of phospholipids and other gummy materials in the oil during degumming process, thus, enhancing it biodiesel conversion yield.

Fuel properties of *Terminalia catappa* methyl ester

The fuel properties of biodiesel from TCSO are presented in Table 3. Acid value is a measure of the number of acidic functional groups in a sample and is measured in terms of the quantity of KOH required to neutralize the sample (Cvengros, 1998). From the table, the acid value of *Terminalia catappa* biodiesel (TCB) is 0.28±0.21 mgKOH/g, which is lower than 0.44 mgKOH/g reported by Atapour and Kariminia (2011) for biodiesel from the same seed oil. The acid value of TCB in this study falls within the acceptable standard of both ASTM D6751 and EN14214 biodiesel standard. The lower acid value suggests high resistance to corrosion due to decrease in free fatty acid content of the biodiesel.

Table 3: Physiochemical properties of *Terminalia Catappa* biodiesel

Properties	Unit	T. Catappa Biodiesel	ASTM D6751 Limits	EN 14214 Limits
Acid value	mgkOH/g	0.28 ±0.21	0.50 max	0.5max
Density	g/cm^3	0.863 ±0.010	*	0.86-0.90
Viscosity (40^{0}C)	Mm^2/s	4.60 ±0.50	1.9-6.0	3.5-5.0
Iodine value	g I_2/100g of oil	72.42 ±1.50	*	120 max
Pour point	^{o}C	2 ±0.00	*	*
Cloud point	^{o}C	8 ±0.00	*	*
Oxidative stability	H	5.8	3 min	6 min
Flash point	^{o}C	153 ±1.50	130 min	120 min
Cetane number		52.84 ±1.50	47 min	51 min
Ash content	% mass	0.014 ±0.001	0.02 max	0.02 max
Water and sediment	% Vol	0.04	0.05max	0.05max
Heat of combustion	Mj/kg	42.76 ±0.52	*	*
FFA	%	0.14	<1%	<1%
Yield of Biodiesel	%	92.68		

* Not specified; Note values are mean ± standard deviation of triplicate determinations.

Also as shown in Table 3, the density of TCB was 0.863 gcm^{-3}, this value is similar to the value of 0.887 gcm^{-3} and 0.873 gcm^{-3} reported by Atapour and Kariminia (2011) and Dos Santos *et al*. (2008), respectively. Similarly, the value is within the range of 0.860 - 0.900 gcm^{-3} specified by EN14214 standard. The kinematic viscosity of TCB, 4.60mm^2/s, was is in close agreements with the values reported by Dos Santos *et al*., (2008); Adewuyi *et al*., (2011) and Giwa and Ogunbona, (2014). Also the value falls within the recommended limits of ASTM D6751 and EN14214 standards for biodiesel.

The iodine value of TCB, 72.42±1.50 gI_2/100g is lower than 83.2 gI_2/100g reported by Dos Santos *et al*. (2008) and higher than 65.30 gI_2/100g reported by Adewuyi *et al*. (2011) for biodiesel obtain from *Terminalia catappa* oil. The iodine value from this study is within the acceptable EN14214 limit.

According to ASTM no limit is specified for pour and cloud point. The reason is that the climate condition in the world vary considerably, thus affecting the needs of biodiesel users in a specific region (Rashid and Anwar, 2008). Pour and cloud points of TCB are 2^{o}C and 8^{o}C respectively (Table 3). In Nigeria TCB will tend to retain it flow properties.

The flash point of TCB obtained was 153 ^{o}C (Table 3). This value is higher than (128 ^{o}C) reported by Adewuyi *et al*. (2011) and lower than (173 ^{o}C) reported by Atapour and kariminia (2011), and is within the approve limit of both ASTM D6751 (130 ^{o}C min.) and EN14214 (120 ^{o}C min.). A higher value of flash point indicates that TCB is safe to handle within the temperature limit.

Oxidation stability is an important technical issue affecting biodiesel quality (Knothe 2008). A minimum rancimat induction period of 3 h and 6 h is defined for biodiesel using ASTM D6751 and EN14214 standards respectively. As provided in Table 3. The oxidative stability (OS) of TCB was 5.8 h, which is higher than the 3.1h, reported by Giwa and Ogunbona (2014); this might be due to difference of the fatty acid composition of the oils. The OS is higher than the recommended ASTM D6751 (3 h minimum) and slightly lower than that specified by EN14214 (6 h minimum). The OS of TCB can be improved by addition of antioxidant but it will increase the cost of biodiesel production. However blending biodiesel with fossil diesel is an inexpensive alternative.

The cetane number of TCB was 52.84±1.50. Giwa and Ogunbona (2014) and Atapour and Kariminia (2011) reported the cetane number of biodiesel from *Terminalia catappa* seed oil as 58 and 44.6 respectively. The different in cetane number might be as a result of differences in the degree of saturation of the oils. Cetane number increases with increase in degree of saturation (Adekunle *et al*., 2016). The cetane number of TCB from this study exceed the minimum standard of 47 set by ASTM D6751 and 51 set by EN 14214.

Ash content describe the amount of inorganic contaminants such as abrasive solid and catalyst residues, and the concentration of soluble metal soap contain in a fuel sample (Fernando *et al.*, 2007). Both ASTM D6751 and EN14214 limit the amount of ash content to a maximum of 0.02 (% mass). The Ash content of TCB was 0.014±0.001% by mass and is within the acceptable standard of ASTM D6751 and EN14214.

Water content of biodiesel reduces the heat of combustion and will cause corrosion of vital. fuel system components; fuel pumps, injector pumps, fuel tubes etc. more over sediment may consist of suspended rust and dust particles or it may originate from the fuel as insoluble compound during oxidation (Dermibas, 2009; Van Gerpen, 2005). ASTM D6751 and EN14214 limit the amount of water and sediment to maximum of 0.05 (%v). The water and sediment content of TCB (0.04 %v) is within the acceptable standards of ASTM D6751 and EN14214.

The heat of combustion or heating value is not specified in the biodiesel standards by ASTM D6751 and EN14214. However European standard for using biodiesel as heating oil specifies a minimum heating value of 35mj/kg (Sokoto *et al*., 2011). The biodiesel obtain from this study have a heating value of 42.76±0.52 Mj/kg; the value is higher than 36.97 Mj/kg reported by Dos Santos *et al.* (2008) and this is due to difference in degree of unsaturation of the oils. Heating value increases with decrease in unsaturation (Sokoto *et al*., 2011). TCB can be a potential alternative to petroleum diesel based on it heat of combustion.

Terminalia catappa biodiesel-diesel blend

Some fuel properties of B6, B10, and B20 blends of TCB in fossil diesel are presented in Table 4 along with ASTM D7467 specification for B6-B20 biodiesel-diesel blend. In the current study, the fuel properties of interest influence by blend ration include ash content, density, viscosity, flash point, cloud point, cetane number, heating value and water and sediment content.

Table 4. Physicochemical properties of *Terminalia Catappa* Biodiesel – Diesel Blend

PROPERTIES	Fossil diesel	B6	B10	B20	B100	ASTM D7467 STANDARD
Ash content % by max	0.01	0.01	0.010	0.010	0.014	0.01 max
Water and sediment % by vol.	0.01	0.01	0.01	0.01	0.04	0.05 max
Density g/cm^{-3}	0.846	0.846	0.848	0.848	0.863	*
Viscosity (40^0C) mm^2/s	3.65	3.65	3.66	3.72	4.60	1.9-4.1
Flash point ^0C	82	85	89	98	153	52 min
Cloud point ^0C	3	3	3	3	8	*
Cetane number	48.50	48.50	48.50	49.20	52.84	40min
Heating value Mj/kg	43.90	43.84	43.72	43.20	41.76	*

* Not Specified

Kinematic viscosity is increased with the carbon length in biodiesel containing free fatty acids and hydrocarbons; hence an increase in biodiesel fraction in the fuel mixture resulted in an increase in viscosity. The allowable ASTM D7467 for B6-B20 biodiesel-diesel blend is 1.9 - 4.1 mm^2/s. The B6, B10 and B20 blends have a viscosity of 3.65 mm^2/s, 3.66 mm^2/s and 3.72 mm^2/s respectively and therefore satisfy the acceptable standard for B6-B20 Biodiesel-diesel blend set by ASTM D7467.

The effect of blending biodiesel and diesel on density was minimal and within a close range of 0.846 – 0.848 gcm^{-3}, this is because the density of biodiesel (0.863 gcm^3) and fossil diesel (0.846 gcm^3) were very close. Dallatu (2015) reported that pig lard methyl ester blends does not show any effect on density because the density of pig lard methyl ester and fossil diesel are similar.

The flash point of biodiesel-diesel blend increases with increase of biodiesel fraction in the blend. The flash point of the biodiesel-diesel blend increase from 85 ^0C – 98 ^0C for B6 to B20 biodiesel-diesel blend. The flash point of B6-B20 biodiesel-diesel blends satisfy ASTM D7467 specification for B6-B20 Blended fuel. Generally all blends are safer for storage and easier for transportation compared to fossil diesel that can easily ignite when expose to spark or flame due to it lower flash point (82^0C).

The cloud point of biodiesel is very important for its use in cold climate country. This is because when a blended fossil diesel is used at low temperature, the biodiesel portion of the blend crystalizes and separate out from fossil diesel (Lang *et al.*, 2001), thereby causes clogging of engine flow system. The B6 - B20 biodiesel-diesel blends have the same cloud points (3^0C) as fossil diesel and can therefore be used in diesel engine.

The cetane number of fossil diesel and biodiesel are 48.50 and 52.84 respectively. There was a steady rise in cetane number with increasing biodiesel fraction in the biodiesel-diesel blend. The cetane number ranges from 48.50 - 49.20 for B6-B20 blends. The cetane numbers of all blends were above the minimum limit of 47 and 40 set by ASTM D6751 and ASTM D7467 for B100 and B6-B20 biodiesel-diesel blend respectively.

The heating value of fossil diesel (43.90Mj/Kg) is higher than that of biodiesel (41.76Mj/Kg) obtain from this study. The heating value for B6, B10 and B20 biodiesel-diesel blend are 43.84 Mj/kg, 43.72 Mj/kg and 43.20 Mj/kg respectively. The increase in ratio of biodiesel in the blend sample lowered the heating value continuously toward the pure biodiesel, suggesting an inverse relationship between the heating value and the blending proportion. The heating value is not specified in the biodiesel standards of ASTM D7467 and EN14214 but is prescribed in EN 14213 for using biodiesel as heating oil only with a minimum of 35 MJ/kg. The difference in heating value between biodiesel and fossil diesel may be due to presence of unsaturated bonds in biodiesel which is absent in fossil diesel. The lower heating value of the biodiesel and blends would lead to higher fuel consumption.

The water and sediments value of fossil diesel and biodiesel are 0.01 and 0.04% respectively. ASTM limits the amount of water and sediment in B100 and B6 – B20 blends to a maximum of 0.05%v. The B6-B20 blends have the same water and sediment value of 0.01%v. Therefore both the biodiesel and the blend are within the standard limit set by ASTM.

ASTM specification, limit the amount of Ash content to a maximum of 0.02%mass and 0.01% mass for pure biodiesel and biodiesel – diesel blend respectively. The ash content of fossil diesel and biodiesel are 0.01 %mass and 0.014 %mass respectively. The B6-B20 biodiesel-diesel blends have an ash content of 0.1 %mass, they therefore satisfy ASTM D7467 requirement for B6-B20 biodiesel-diesel blend.

CONCLUSION

The oil content of *Terminalia catappa* seed oil was high enough to be classified as economically viable source for biodiesel production. *Terminalia catappa* biodiesel (B100) and B6-B20 biodiesel-diesel blend satisfy ASTM D6751 and ASTM D7467 standards, respectively. Therefore *Terminalia catappa* biodiesel can be used as a separate fuel (B100) and the biodiesel-diesel blend of B6-B20 can be used as blended fuel in any diesel engine. The utilization of *Terminalia catappa* biodiesel blend will provide sustainability to the current energy system and greener fuel.

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