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Research Paper

FUEL PROPERTIES OF BIO-DIESEL FROM *Hydnocarpus weightiana* SEED OIL, ITS METHYL ESTER AND ESTER DIESEL BLENDS WITH PETROLEUM DIESEL

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Abstract

Many researchers have worked on the use of edible seed oil as feed stock for biodiesel production. Since this practice poses great challenge to food security, *Hydnocarpous Wieghtena* (a non edible seed) oil was analyzed to determine if it could suitably be used as substitute for petroleum diesel. The seed oil *was* extracted using Soxhlet extractor and petroleum ether as solvent. The seed oil extracted gave percentage oil yield of 55%. The oil was reddish in color. The methyl ester of the oil was prepared using methanol and H_2SO_4 as catalyst. Prepared methyl ester of the oil was blended with Petroleum diesel in the ratios of 10:90, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, 80:20 and 90:10. The oil, its methyl ester and methyl ester blends were analyzed comparatively with automotive gas oil (AGO) for their fuel properties including relative density, Viscosity, calorific value, flash point, pour point, ash content and acid values. The fatty acids present in the oil were determined using GCMS. The result obtained showed that the *Hydnocarpous Wieghtena,* seed oil, its methyl ester, and its methyl ester blends with petroleum diesel are comparable in properties to diesel oil obtained from petroleum refining.

Key words: Biodiesel, Methyl ester, Viscosity, Extraction, Non-edible Oil.

INTRODUCTION

When the diesel engine was invented, Bio- diesel was the first liquid fuel used apart from coal dust [1]. Due to economic reasons, they were abandoned for fossil diesel which is cheaper compared to bio- diesel. Vegetable diesel (Biodiesel) refers to a non-petroleum-based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters, made by trans-esterification of vegetable oils which can be used (alone, or blended with conventional petrol diesel) in unmodified diesel-engine vehicles [2,3].

Although fossil fuels are extremely useful for many years its surplus availability as primary source of energy did not encourage research work. However, the issue of environmental pollution caused by fossil diesel combustion and the fact that the world is running out of fossil diesel has made scientist all over the world sought for an alternative. Biodiesel is therefore the alternative that can ensure that the environmental pollution and its grave effects can be minimized. [4] Study has shown that oils from edible seed oils like palm, palm kernel, melon, soya been, pea nut, etc their alkyl (methyl or ethyl) ester as well as their blends with fossil diesel has similar properties like fossil diesel and can be used as a replacement for them [5,6,7,8]

Many arguments has taken the stage on the use of edible seed oils for bio-diesel production, some argued that there will be scarcity of those oils in the sector where they are needed most and it can consequently challenge food security [9]. These researches are aimed at assessing the use of non-edible seed oil of (*hydnocarpus weightiena*) for bio-diesel production and assessment of the fuel properties of the oil, its methyl ester and ester diesel blends [10]. The research aimed at replacement of fossil diesel that is constantly depleting and that has numerous pollution issues [11].Their fuel properties were comparatively studied with the automotive grade diesel fuel.

Hydnocarpus weightien is a tropical tree introduced in Nigeria by German missionaries around 1950s. It was planted in leprosy colony present day General hospital Oji River. In Oji River Local Government Area of Enugu state Nigeria. It's an evergreen tree that grows up to 10 – 15ms. It is well adapted to our local climate. The tree produces a lot of fruit and has seed that looks brown like palm kernel. It was known that the oil was used in the early treatment of leprosy but was abandoned due to it adverse side effects. No work is known to have been done in the use of *Hydnocarpus weithiena* for bio-diesel production. Neither is there any information about their fuel properties before now. Little is known about the oil.

MATERIAL AND METHODS

The samples of *Hydnocarpus weightiena* were collected from leprosy colony around The General Hospital Oji River. The seeds were collected isolated from the husk, ground and dried for 2 to 3 days, oil was extracted from the powdered seed according to the method described by Ajiwe et al. (1995) Enestino ,1976, Danian, and, Milford, (1996) [12,13]. The oil was purified by using it to prepare soap and the soap was re-dissolved in boiling water and acidified with 1:1 HCl. The fatty acid mixture was then methylated with methanol in the presence of 1:3 H_2SO_4 . The methyl ester was formed after heating the mixture to boil. The methyl ester was separated with separation funnel [14]. The methyl ester was blended with diesel in the ratio 10:90, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, 80:20, 90:10. (AGO). The extracted oil, its methyl ester and methyl ester blends with diesel were comparatively analyzed for their primary fuel properties such as acid value, relative density, water content, viscosity, calorific value, ash content, carbon residue and flash point. Relative density, calorific value and water content. They were determined by the methods outlined by [15,17] respectively. The acid value was determined by method outlined by Mahattan, [14,16]. While the kinematic viscosity was determined by the institute of petroleum standard method (IP) [18]. The flash point and carbon residue were determined by the American society for testing and material (ASTM) method 1985 [19].

RESULTS AND DISCUSSION

The result of comparative analysis of *Hydnocarpus weightiena* oil, its methyl ester and methyl ester diesel blends are presented in Table 1 – 2. Table 1 shows few properties of *Hydnocarpus weightiena* seed oil and its methyl ester.

The oil from *Hydnocarpus weightiena* was dark red in color but its methyl ester was yellow. The percentage oil yield of *Hydnocarpus weightiena* was 55.00%. The percentage oil yield of *Hydnocarpus weightiena* compared favorably with majority of the known seed oil like soya been (11.25%) cotton (18.28) Triculia africana (45.00%).(Ajiwe, 1998) The oil yield was high due to that, commercial extraction of the oil is possible. The oil will be best extracted by solvent extraction. *Hydnocarpus weightiena* oil had ash content of 0.1 % which showed that it had low quantity of micro elements. The low ash content also confirmed that the oil contained burnable materials which make them less likely to contribute to injector, fuel pump, piston and rings wear. The high calorific values for the samples showed that the seed oil has high energy content hence it will give off energy that will be utilized to power the engine.

Table 2 shows the comparative analysis result of *Hydnocarpus weightiena* oil, methyl ester, and ester blends with diesel. With regards to moisture content, showed that the samples did not contain much moisture. ASTM permitted about 0.25% of water although the water is regarded as a contaminant and poses serious corrosion danger to the engine if the water was salty. The ash content of *Hydnocarpus weightiena* seed oil is in conformity with the American Standard for Testing and Materials (ASTM) limiting requirements. This means that the oil contained low non combustible materials that made them less likely to contribute to injection fuel pump, piston and rings wear. The flash point of *Hydnocarpus weightiena* alongside their methyl ester diesel blend placed the oil in No 1 and No 2 grade diesel fuel. The flash point of the samples fell within 36 and 82^{0}C. The flash point of *Hydnocarpus weightiena* methyl ester is 46^{0}C while that of fossil diesel is 36^{0}C the result of the analysis showed that the samples could be stored below these temperatures. The storage temperature showed also that they might not constitute a fire risk. The flash point of *Hydnocarpus weightiena* methyl ester and diesel ester blend ranged from 38 and 50^{0}C . None of the blends has flash point corresponding to that of fossil diesel (36^{0}C)**.** It was observed that at **100^{0}C** the viscorsity of 20H:80D, 30H: 70D, 40H: 60D, 50H:50D, 60H:40D blends of *Hydnocarpus weightiena* methyl ester and ester fell within the 1D diesel fuels While the 80H: 20D and 90H: 10D, are placed in the grade 4D *for Hydnocarpus Wightiena*. **At 70^{0}C** the lower temperatures had a pronounced effect on the viscosities of the samples (blends). For *Hydnocarpus weightiena* 70^{0}C placed them in grade 2D and 4D diesel fuels (2- 4.3) and (5.8 – 26.4) mm^2/s. The viscosity of the oil, methyl ester and diesel blend ratio from 10H:90D to 60H:40D were placed in grade 2 while 80H: 20D and 90D:10H were placed in grade 4 diesel fuels for *Hydnocarpus weightiena.* **At 40^{0}C** 10H:90D – 30H:70D fell into grade 2 diesel fuels while 40H: 60D – 90H:10H plus 100% methyl ester fell into grade 4D diesel. At the three different temperatures studied it could be seen that the viscosity of the diesel oil decreased from 2.461 to 1.51 and 1.3 as temperature increased. All the other of blends had similar increase. However, the blend ratio of 10H: 90D did not fit into specified fuel properties of diesel fuel as stipulated by ASTM but is in consonance with the diesel fuel that was used as standard. The viscosity of both diesel and methyl ester blends showed that the oils, their methyl ester and diesel methyl ester blends showed that the oil, their methyl ester and diesel ester blends were sufficiently viscose and that the real spray would penetrate across the combustion chamber and will be well atomized. It could be observed that blending of biodiesel with fossil diesel at 100^{0}C gave a reduction in the viscosity of the biodiesel. The results showed that the oils, their methyl ester and diesel methyl ester blends were more efficient at higher temperature.

Results showed that the acid values of the oils, their methyl ester and diesel methyl ester blends are relatively low in terms of mg/g .The acidity came from the fatty acid component of the oil. The fatty acid composition of the sample was greatly reduced during saponification and esterification and cannot cause corrosion in the diesel engine. The acid vale of the samples were close to that of the fossil diesel. Blending dilutes both sulphur and aromatics in fossil diesel fuel. From the analysis result, the acid vale, sulphur , and aromatics reduction was evident in the reduction of carbon residue of blends from 10H: 90D to 50H:50D. It confirmed that mere dilution of the fossil diesel could improve engine performance. The densities of the oils, their methyl ester and diesel methyl ester blends were very close to that of fossil diesel. Especially the blend ratio of 30H: 70D, were exactly in conformity with that of fossil diesel. The relative densities of the oils, their methyl ester and diesel methyl ester blends were in conformity with ASTM (1985) requirements. This implied that the oil had good combustion characteristics, the similarities also confirmed that the oils, their methyl ester and diesel methyl ester blends could suitably substitute fossil diesel. The density tends to increase with the increased in blend ratio (dilution) although there are exceptions ac could be seen from table 2. Their relative densities were very low and this indicated good ignition properties. Literature showed that high relative density mainly indicated aromatic asphaltic fuel with poor combustion properties (ASTM,1985) [20].

The calorific vale of the oils, their methyl ester and diesel methyl ester blends are very high which indicated that the fuels when combusted would give high energy that could be used to drive diesel engine. The pour point of the samples indicated that they are good bio-fuels *Hydnocarpus Weightiena* methyl ester could pour at -3^{0}C while fossil diesel could pour at 9^{0}C. The rest of the blends could pour at the temperature were pure water will not pour. The pour points could be clearly seen in Table 2. Vegetable oil rich in mono unsaturated fatty acids, their methyl ester should have good flow characteristics at low temperature. The result of the pour point confirmed that the fatty acids of the oil were mono unsaturated and that the fuel will hardly congeal in the engine.

GCMS was used to identify the compounds (fatty acids) present in *Hydnocarpus Weightiena. T*he result indicated that Palmitic acid, Myristic acid, Steric acids and Linolic acid were the fatty acids present. From Table 3 it was clear that the properties of the triglyceride of the vegetable oil used for the bio fuel production are determined by the amount of each fatty acid present. Chain length and the number of double bond determine the physical characteristics of the fatty acid and triglyceride. Study has shown that Trans -esterification does not alter the fatty acids. Trigriceride can be mono, double or poly unsaturated. The quality of fuel can be affected by fatty acid present. if the degree of unsaturation is high, the oil will tend to have high freezing point. Those with unsaturated and mono saturated fatty acids cannot polymerize at high temperature and have good oxidation stability with good flow characteristics at low temperature and can be ideal. Such are the fatty acid of *Hydnocarpus Weightiena* seed oil which has mainly saturated and mono unsaturated fatty acids.

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Table 1; Characterization of *Hydnocarpus weightiena* oil

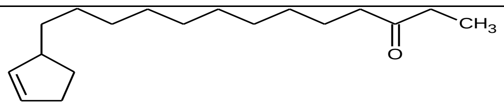
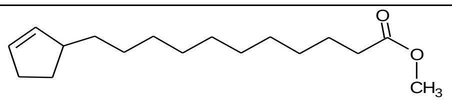
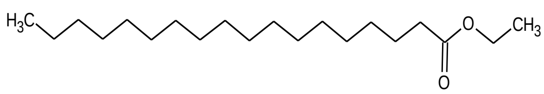
Hydnocarpus weightiena oil parameter in mg/g	Values.
Percentage oil content 0il color Color of the methyl ester Calorific value	55.00% Dark red. yellow 45.12

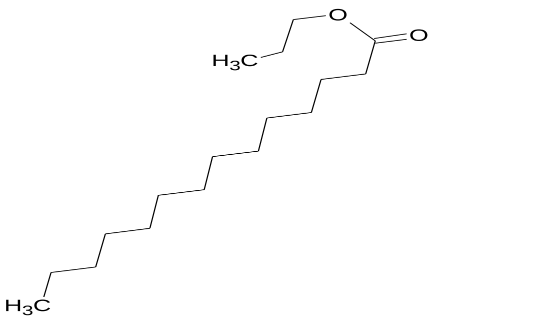
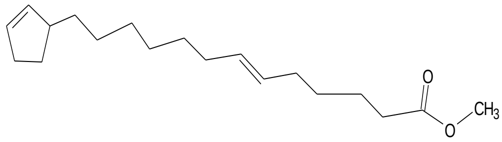
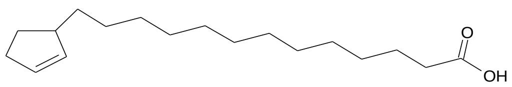
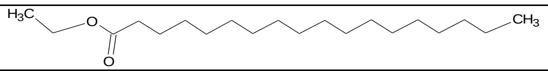
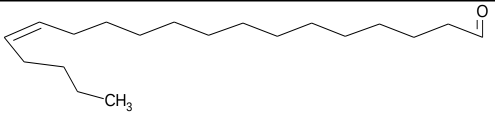
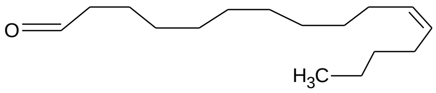
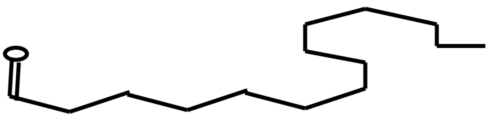
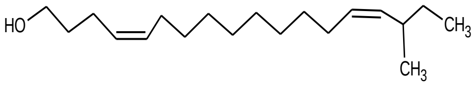
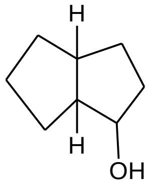
Table 2; Comparative analysis of *Hydnocarpus weightiena* oil, Methyl ester, and Ester blends with diesel

Blends ratio	Ash content	Viscosity @ 40^{0}C	Viscosity @ 70^{0}C	Viscosity @ 100^{0}C	Pour point	Flash point	Water crackle point density	Calorific value(KJ/Kg)	Acid value	Carbon residue.
10H:90D	0.0034	1.26	2.19	3.64	- 7	50	0.88 -	44,752	1.32	0.07
20H:80D	0.0050	1.57	2.28	4.10	- 6	40	0.90 -	44,357	1.45	0.05
30H:70D	0.0075	1.69	2.77	4.14	- 8	42	0.83 -	45,729	1.52	0.12
40H:60D	0.0021	2.03	3.56	7.32	- 8	42	0.86 -	45,124	1.60	0.17
50H:50D	0.0100	2.16	4.07	5.84	-8	40	0.87 -	44,938	1.40	0.59
60H:40D	0.0020	2.50	3.95	7.77	- 5	42	0.87 -	44,983	1.50	0.77
70H:30D	0.0021	2.81	4.48	10.35	- 4	38	0.88 -	44,752	1.60	0.93
80H:20D	0.0023	3.22	4.96	12.25	- 4	39	0.88 -	44,752	1.70	1.01
90H:10D	0.0025	3.63	5.59	13.05	- 3	38	0.88 -	44,752	1.75	1.03
100%Hme	0.0020	4.03	6.88	17.99	9	46	0.86 -	45,124	50.49	ND
100%D	0.0200	1.13	1.51	2.46	7	36	0.87 -	44,938	0.23	0.17

H= *Hydnocarpus weightiena* methyl ester, D= Petroleum diesel (AGO).

Table3. Compounds present *in Hydnocarpus Weightena* methyl ester as revealed by GCMS

Formula	Name of compound	Structure	Fatty acid.
$C_{18}H_{32}O_2$	2-cyclopentene-1-undecanoic acid		Undecanoic acid.
$C_{17}H_{30}O_2$	2-cyclopentene-1-undecanoic acid		Undecanoic acid.
$C_{18}H_{36}O_2$	Hexsadecanoic acid		Hexadecanoic acid.

$C_{17}H_{34}O_2$	Pentadecanoic acid		Pentadecanoic acid
$C_{19}H_{38}O_2$	Heptadecanoic acid		Heptadecanoic acid
$C_{19}H_{32}O_2$	6-Indecanoic acid		6-Indecanoic acid
$C_{18}H_{32}O$	17-Octadecen-14-yl-1-ol		-
$C_{18}H_{32}O_2$	2-Cyclopentene-1tridecanoic acid.		Decanoic acid
$C_{20}H_{40}O_2$	Octadecanoic acid.		Octadecanoic acid.
$C_{18}H_{34}O$	13-Octadecenal		–
$C_{16}H_{30}O$	Cis-11-hexadecenal		–
$C_{14}H_{26}O$	9-teteradecenal		
$C_{19}H_{35}O$	2-methyl-Z,Z-3-13octadecadienol		–
$C_8H_{14}O$	Octahydropentalen-1-ol		–

CONCLUSION

The bio-fuel properties of the oil , methyl ester, and diesel methylester blend of *Hydnocarpus Weightiena* Have confirmed that they could be use as alternative as alternative diesel. *Hydnocarpus Weightiena* had also been confirmed as sustainable feed stock for bio fuel production. It could be classed among the seed that can be used for waste to wealth venture especially due to it very high oil content. Since no work is known to have been done on the fuel properties of the seeds oil, the research is now a stepping stone to other works that could be done on this plant. *Hydnocarpus Weightiena* had been confirmed to have oil yield close to *Jactropher Curcas* .

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