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Vegetable diesel fuels from *Luffa cylindrica* oil, its methylester and ester-diesel blends

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ABSTRACT

With regard to industrial and technological development, the cost of fuel is on the increase. Based on this, *Luffa cylindrica* oil was extracted, its methylester was prepared and the fuel properties such as flash point, acid value, relative density, viscosity, carbon residue, ash, moisture and calorific value were determined. Atomic absorption spectroscopy result of the microelement composition of the samples showed that the metallic contents would not cause corrosion. Fourier Transform Infrared[FTIR]spectroscopy was used to compare the samples' bond structure/stability with diesel. The results showed that *Luffa* oil, methylester and ester/diesel blends had similar fuel properties with diesel oil. These results confirmed that *Luffa* methyl ester and its blends could be used as substitutes for diesel oil in grade one diesel engines, and that the *Luffa* oil could be used to drive class 4-D diesel engines. It has been recommended that *Luffa* seed, though a waste should be processed since it has a high percentage oil content.

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INTRODUCTION

With regard to industrial and technological developments, effort is geared toward the provision of raw materials that could be used in the production sector. There are only a few sources of the majority of oils. Emphasis is being made about the way and manner edible fruits (seeds) and non-edible ones, which sometimes constitute environmental problem, could be gainfully utilized [1]. Plant sources of oils and fats are from nuts and seeds. Effort is being made towards the possibility of harnessing, converting and recycling these waste seeds from edible fruits and those regarded as weeds (non-edible ones), like *Luffa cylindrical* into industrial, domestic or technological resources. Fats and oils were used as the fuel for diesel engines but were dropped for the cheap fossil diesel due to discovery and use of petroleum–based fuels in the 20th century [2]. Though fossil fuel has an economic advantage, its immediate and past impact on the spillage and pollution of the environment has done much to destroy the life of the communities and vegetation. This necessitated further research for vegetable seed oils as alternative source of diesel fuel [3-7].

Lufa cylindrica is a plant commonly found in the tropics. It is a herbaceous plant and it thrives commonly with twinning tendrils. The plant has conspicuous leaves, which are attached alternatively to the hairy hollow stem; the corolla is 5-lobed and is found within the clay, which is a dentate to the inferior ovary. It produces berry like fruit whose colour at tender stage is green and yellow at maturity. The fruit could be borne in a bulky or singly stalk as the case may be. The fruit has fibrous mesocarp, which is used locally as sponge. The spongy part contains several black seeds and it is propagated by seeds and it grows well at the onset of rain [8].

Apart from the work done on the crude drug activity of the *Luffa cylindrica* oil [9], no work has been done on the fuel properties of the oil.

EXPERIMENTAL

The *Luffa cylindrica* fruit in this work was collected from a small bush at Awka in Anambra state, Nigeria. The *Luffa* seeds were ground to a fine particle size and was sun dried for three days. The diesel oil was bought from a petrol station in Awka. Extraction of oil from *Luffa cylindrica* was done by soxhlet extraction system using the method of the America Oil Chemists Society, 1960 [10]. The solvent used for the extraction was petroleum ether [60-80^{o}C].

Methylester sample preparation

The methyl ester samples were prepared by saponification of the fruit oil sample, acidification of the soup followed by methylation (esterification) of the fatty acid so formed using the method outlined by Ajiwe, *et al.* [11]. The methyl ester was blended with a standard automotive gas oil (AGO) in the ratios 10:90, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, 80:20, 90:10 of *Luffa* methyl ester to diesel oil [12].

Analysis of the samples

The extracted oils of *Luffa cylindrica*, the methyl ester, the methyl ester blends with diesel and the diesel oil (AGO) were comparatively analyzed for their primary fuel properties such as relative density, carbon residue, viscosity, flash point, calorific value, total acid value, ash and moisture.

Equally, the bond structure stability relationship for the samples was determined using Fourier Transform Infrared [FTIR] spectroscopy. The relative density, calorific value, carbon residue, viscosity, acid value, ash and moisture were determined by the methods prescribed by the American Standard for Testing and Materials (ASTM), 1985 and that of the Institute of Petroleum Standard (I.P), 1983 [13-14]. The microelements were determined by Atomic Absorption Spectroscopic [AAS] method using Unicam 969 spectrometer coupled to a computer software.

RESULTS AND DISCUSSION

The results obtained from the physico-chemical analysis of *Luffa cylindrica* oil, its methyl ester, and ester blends with diesel oil have shown that alternative diesel oil could be obtained from *Luffa cylindrica* oil; using petroleum diesel as a standard, they had similar physico-chemical results especially the blended oil ester (Table 1). The resulting densities of *Luffa cylindrica* oil methyl ester and blends with diesel oil were in conformity with ASTM requirement [13]. This meant that the oil has good combustion characteristics. This similarity in their density values also confirmed that diesel oil could be substituted with the *Luffa* oil, methyl ester and methyl ester blends. The low value of the relative density of the *Luffa* methyl ester indicated good ignition property. Literature [15] has shown that high relative density indicates mainly aromatics or asphalted fuels with pour combustion properties. The calorific values of the samples and the diesel oil were very closely related and the values were quite high. This showed that the *Luffa* oil, *Luffa* ester, ester/ diesel blends could power a diesel engine. Since cetane number of diesel fuels are related to their hydrocarbon chain length, the infrared bond structure of all the samples showed that they were similar to that of diesel, hence, their cetane number must also be close to that of diesel.

Table 1: Comparative analysis result of *Luffa cylindrica* oil, methylester, ester blends with diesel and diesel

Sample	Flash point ^0C	Relative density at 15^0C	Carbon residue % wt	Moisture content % wt	Ash content %wt	Calorific value kJ/kg	Viscosity mm^2/s	Acid value in mg/g KOH
Diesel	93	0.8601	0.68	-	0.02	45124	1.90	0.31
Luffa	120	ND	ND	0.03	0.0045	ND	6.10	0.70
Ester	90	0.8701	ND	0.01	0.002	44938	1.79	0.38
10L:90D	75	0.8604	0.37	0.02	0.0034	45124	1.80	0.48
20L:80D	85	0.8723	0.75	0.04	0.0050	44938	1.90	0.35
30L:70D	83	0.8683	0.67	0.02	0.0075	44938	1.80	0.28
40L:60D	75	0.8665	0.67	0.00	0.010	44938	1.70	0.36
50L:50D	72	0.8980	0.59	0.05	0.0021	44357	1.65	0.38
60L:40D	62	0.8851	0.77	0.05	0.0020	44543	1.62	0.37
70L:30D	70	0.8838	0.93	0.07	0.0021	44752	1.60	0.38
80L:20D	82	0.8836	1.01	0.06	0.0023	44752	1.55	0.33
90L:10D	61	0.9068	1.03	0.06	0.0025	44147	1.52	1.52

The results of the comparative analysis of the sample and diesel oil are given on Table 1, 2 and 3. Table 1 showed the comparative analysis of *Luffa cylindrica* oil, methyl ester, ester blends with diesel, while Table 2 showed the Fourier Transform Infrared spectra for bond structure/stability relationship with diesel at 28^{o}C. Table 3 depicted the trace metal composition of the samples in relation to diesel oil (AGO).

The oil obtained from the seed was pale yellow in colour and the percentage oil yield was 31.6% and compared favourably with the oil content of such seeds as cotton 18.28% and soya bean (11-25%) which are commonly extracted by the solvent extraction method.

The stability of the sample when compared to that of diesel showed that the samples were stable at 28^{o}C. Their stability at high temperatures were not tested. The flash point of *Luffa* samples ranged from 61-120^{o}C, confirming that the fuels from this oil would not constitute a fire risk. The moisture and ash content of the sample conformed with the ASTM, 1985 and IP, 1983 standards [13-14]. The trace metal composition of all samples as shown (Table 3) was below that of the

Table 2: Fourier transform bond structure/stability. comparism for *Luffa cyclindrica* oil, its methylester, ester/diesel blends and diesel (CM $^{-1}$) at 28^{o} C

Luffa cylindrica oil	***Lufa*** methyl ester	Diesel	10:90 Ester diesel	20:80	30:70	40:60	50:50	60:40	70:30	80:20	10:90	Description
3472	3472	3478	3472	3473	3471	3472	3446	3472	3472	3472	3472	Free O-H Stretch
3008	3008	-	3178	-	3182 3007	3008	3008	3008	3008	3008	3008	O-H Stretch
2926	2926	2925	2925	2925	2926	2926	2926	2926	2926	2926	2926	C-H stretch for Alkenes and Aromatics
2855	2855	2855	2855	2854	2855	2855	2855	2855	2855	2855	2855	C-H stretch for Alkenes
1745	1745	1746	1748	1747	1747	1746	1746	1746	1746	1746	1745	C-O stretch for esters
		1604	1604	1604	1604	1619						
1463	1463	1460	1460	1460	1460	1461	1459	1462	1462	1462	1463	C-C double bond for esters & alcohol
1378	1378	1377	1377	1377	1377	1377	1380	1378	1377	1377	1378	C-O stretch for esters and esthers
1238	1239	-	-	1240	1240	1239	1237	1239	1239	1239	1239	
1164	1165	1164	1163	1163	1163	1164	1160	1164	1165	1165	1165	C-O deformation bond for esters
1100	1100	1133	1100	1100	1100	1100	1199	1118	1100	1100	1100	C-H deformation for alkyl and aryl groups
915	915	857	1033	1033	1033	1034	1034	1034				
-	-	811	811	812	812	812	-	-	-	-	-	
723	723	723	723	723	723	723	723	723	723	723	723	C-H deformation for methyl groups
583	602	-	-	-	-	-	537	-	583	583	594	C-H deformation for alkyl groups

L =*Lufa cylindrica*; D =Diesel

standard diesel. These values confirmed that all *Luffa* vegetable fuels would not constitute a corrosion problem in the injection and piston chambers of the diesel engines. The acid values of the oil ester and blends are almost on the same range with diesel but are low in terms of mg/g of fuel. It was worthy to note that the acidity comes from the fatty acid composition of the oil unlike that of fossil diesel, which comes from sulfur. The reduction of acidity to an average of 0.05 percent often increased the life of engines by 30%. This reduction would increase the cost of fuel by 1.5% per gallon. The reduction in acidity and cost of fuel would come from *Luffa cylindrica* alternative fuels. It was obvious that conversion of the oil to methyl ester followed by addition with diesel would reduce acidity and carbon residues as seen in the samples 10:90 to 60:40 ratios. The carbon residue increased with increase in vegetable ester ratio. This confirmed that the 40:60,50:50 and 60:40 dilutions are the best commercializable blends. The viscosity of the oil, methyl ester and the blends are quite close to that of diesel and showed that they are sufficiently viscous and that real spray would generate across the combustion chamber and this would be properly mixed with air. Lufa oil viscosity fell within the 4-D grade diesel fuel while the *Luffa* methylester and other ester-diesel blends fell within the 1-D grade diesel fuels. The fluidity of the Lufa methylester at cold temperatures below 28^{o}C placed it as a good biofuel.

CONCLUSION/RECOMMENDATION

From the result of the extraction and physico – chemical analysis and discussion, it was obvious that *Luffa cylindrica* oil is a very important source of fuel for diesel engines. This suggested that the extraction of the oil on a commercial scale was possible. It could be recalled that the high viscosity of vegetable oil and other impurities could be eliminated by conversion to

Table 3: the trace metal content for the comparative study of *Luffa cylindrica* oil, methylester/diesel blends and diesel oil (ago) in relation to corrosion mg/g

Metal	*Luffa cylindrica* Oil	*Luffa* methyl ester	Diesel	10:90 Ester diesel	20:80 Ester diesel	30:70 Ester diesel	40:60 Ester diesel	50:50 Ester diesel	60:40 Ester diesel	70:30 Ester diesel	80:20 Ester diesel	10:90 Ester diesel
Mg	0.867	0.513	1.497	0.652	0.579	0.696	0.506	0.394	0.676	0.493	0.507	0.475
Fe	3.089	5.916	6.300	2.034	2.53	3.473	5.593	1.563	8.859	2.304	3.220	2.679
Cu	0.7250	0.737	1.165	0.350	0.3800	0.410	0.434	0.501	0.555	0.574	0.604	0.658
Cr	5.694	1.263	4.141	0.849	1.656	3.956	1.077	0.352	1.470	2.464	3.768	4.017
Mn	0.145	0.163	0.143	0.080	0.091	0.074	0.082	0.097	0.127	0.105	0.177	0.170
Ag	0.144	0.067	0.166	0.089	0.156	0.138	0.055	0.072	0.066	0.044	0.033	0.028
Pb	0.189	0.1343	0.8454	2.135	2.034	2.155	1.575	1.585	2.889	2.068	0.821	0.5121
Cd	0.010	0.010	0.006	0.013	0.012	0.012	0.011	0.011	0.010	0.013	0.012	0.011

form ester [6-7]. This has been confirmed by the results. It has been recommended that blending of diesel and seed oil methyl ester should be done to conserve fossil diesel and reduce environmental pollution. Equally, the use of *Luffa* oil for diesel fuels will mean a better use of the waste fruit/seeds.

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