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Preliminary investigation of the fuel properties of three vegetable oils from Nigeria

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ABSTRACT: The ever-increasing price of petroleum products coupled with global climate change, environmental pollution and limited availability of fossil fuel called the need for renewable fuels. Biofuel from biomass, spent oil is such a renewable fuel with the added advantage of also cleaning the environment. Therefore, this research reports the Biofuel potential of the seed oil of Zizyphus abyssinia, Zizyphus jujube, and Olea europeae. The seeds extracted with petroleum ether gave low yield and the physical, chemical and fuel properties of the oil were determined. Meanwhile, the extracted oils were golden yellow in colour. The flash point, pour point, viscosity, refractive index, and specific gravity were determined and the Flash point was 118^{o}C, 141^{o}C and 218^{o}C respectively. The pour point was 6^{0}C, 8^{o}C and 9^{o}Crespectively.Whereas, the carbon residue was (0.85 and 2.00%); and percent Sulphur was (0.026 and 0.066%). Then the ash content was (0.72, 0.75 and .0.77%). The fuel properties were within the limits for biofuel. Other parameters determined included viscosity (46.31, 41.00 and 40.04), refractive index (1.453, 1.450 and 1.471), specific gravity (0.993, 0.893 and 0.787) and distillation profile. From the result, the oils have the potential for biofuel production either as the raw oil or chemically modified to the methyl or ethyl ester.

Key points: Fuel properties, Olea europeae, Zizyphus abyssinia, Zizyphus jujube, Seed oil

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INTRODUCTION

The conversion of waste biomass into biofuel is an environmentally friendly and sustainable method of waste management [Adegbuyi et. al., 1996; Hill *et. al.*, 2006]. It also produces a useful resource. In addition to leaving behind a cleaner and better environment [Hill *et al.*, 2006].Globally, biological materials and their derivatives are useful for biofuel production [Foidl *et. al.*, 1996; Kubmarawa *et. al.*, 2007 and Kagoro *et al.*, 2011]. Soybean, Jatropha curcas, rapeseed and hemp are good examples. The biofuel from soybean accounts for about nine percent of all biofuel feedstock in the US. Traditionally, plants, animals, wastes, algae and halophytes are sources of biofuel, such that the biofuel industry is fast growing & evolving (Barnwal and Sharma, 2005; Ejikeme, 2007;Ibemesi *et al.*, 1991). Nigeria, cannot therefore afford to neglect this emerging technology.

Furthermore, we hope that more resources be harnessed to the production of biofuel from agro Residues as their benefits include renewability and low emission of greenhouse gases (USEPA,, 2010).In addition, the biofuel from waste reduces greenhouse gases by 82% (USEPA, 2010).

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However, those from food plant resources such as soya oil the reduction is less at 57% (USEPA, 2010). Moreover, the carbon residue is very low so more beneficial to the vehicular exhaust system (Wilson *et al.*, 2011).

In Nigeria, oils from the seeds of Zizyphus abyssinia, Zizyphus jujube and Olea europeae seeds are feedstock for biofuel production. Their fuel properties however had not being exploited. These plants have edible fruits however; of the oils only that of Olea europeae is edible in Nigeria. Despite the fact that the oil of Zizyphus abyssinia and Zizyphus jujube are edible vegetable oils in India and the Middle East. Meanwhile their seeds are used as landfills or burnt with leachates that could be harmful to the environment, in addition to the probable inorganic contamination of groundwater. This research therefore reports the fuel properties of these Oils for the first time.

Thus, the study aims at extracting oil from these seeds with petroleum ether (30-70^{o}C) and determining the fuel properties of the extracted oils. The results will be compared with Jatropha curcas oil, which is currently in use as a biofuel.

MATERIALS AND METHODOLOGY

Sample collection/Treatment

We obtained the seed samples from new market in Jos North, Plateau State, Nigeria. The identification and authentication was by Mr. Arzila of the Federal College of Forestry, Jos Plateau State. The seeds were handpicked then washed and dried. The dried seeds ground to powder.

Extraction

The weighed seeds was poured into the thimble then placed inside a Soxhlet extractor and extracted continuously for nine hours using petroleum ether. The petroleum ether recovered in vacuum.

Flash Point Determination: The flash point was determined using Abel's apparatus, such that the test samples were placed in a small metal cup surrounded by water bath and then heated slowly. The lid of the metal cup opened from time to time and the vapour of the oil ignited by a tiny flame. The temperature at which the oil vapour burned with slight explosion was noted as the flash point.

Pour Point Determination: The oil samples (2mL) was dispensed into a test tube and inserted into an ice bath. The temperature at which the oil seizes to flow is recorded as the pour point.

Refractive Index Determination: Was determined using a refractometer. A small quantity of the oil was taken and smeared on the refractometer prism. A constant light source was allowed to pass through the smeared oil on the prism and the result read from the calibration.

Viscosity Determination: Ostwald's viscometer was employed to determine the viscosity and a stopwatch. The Ostwald viscometer has two points' labeled A and B and was clamped using a retort stand and clamp.

The solvent (n-hexane) was poured into the viscometer to point A and allowed to flow. The time it took the solvent to flow from A to B was noted. Similarly, the sample (oil) was poured and allowed to flow and the time it took the sample to flow from A to B was noted.

Calculation

$$\text{Viscosity} = \frac{Ts - To}{To}$$

Ts = time it took sample to flow from A to B

To = Time it took solvent to flow from A to B.

RESULTS AND DISCUSSION

Table 1: Physico-Chemical Properties of Extracted Oil

OIL SEED	Specific gravity	Refractive index	Moisture content	Ash content (%)	Carbon residue (%)
Olea europeae	0.839	1.453	6	0.720	0.850
Zizyphus abyssinia	0.799	1.450	8	0.770	2.00
Zizyphus jujube	0.993	1.420	5	0.750	ND

Table 2: Fuel Properties of the Extracted Oils

Oil Seed	Flash point ^{o}C	Pour point ^{o}C	Cloud point ^{o}C	Viscosity@40^{o}C
Olea europeae	218	8	11	46.31
Zizyphus abyssinia	118	9	12	41.00
Zizyphus jujube	141	6	ND	40.04

The moisture content of 6, 5 and 8% for the seeds of Zizyphus abyssinia, Zizyphus jujube and Olea europeae indicates long shelf life. Since spoilage due to microbial attack will be highly minimized, Table 1. The oil content of 28.38, 30.45 and 32.11% respectively is low, relative to oil palm, rapeseed, peanut, and benniseed. They however, compare favourably with Jatropha curcas and soybeans, which have an average oil content of 34.4 and 25% [Fukuda *et al.*; Anyanwu et al 2011]. Currently, the oil of the seed of Jatropha curcas is in use as a biofuel. From the results obtained in Table 2, the viscosity, pour point and flash point, indicate the oils will pump and flow well. Viscosity is a measure of friction, heat generation and rate of flow under specified conditions of speed, load and design (Sharma, 2002), it follows those oils with low viscosity index its flow rate will decrease rapidly with temperature and vice versa. Meanwhile, viscosity depends on molecular structure and weight, therefore any oil with high molecular weight possesses high viscosity as well as high boiling point (Sharma, 2002). From Table 2 the viscosity of Olea europeae is the highest at 46.31 implying it is made of higher molecular fatty acids than both Zizyphus jujube and Zizyphus abyssinia. In addition, its ash content is least implying low involatile residue and that causes wear and tear to the vehicle. Moreover, the specific gravity a measure of how heavy a substance is also indicated the heaviness of the oil of Olea europeae. The viscosity of the oils fell within those of common oils such as those of soybeans and also those of nonconventional oils like Jatropha curcas and tigernut (Barminas *et al.*, 2001). This is also within the range for petroleum-based diesel. Nevertheless, comparing the fuel properties of the extracted oils with standard biofuel guidelines of other countries, its values fell within those of most countries for the pour point, flash point and viscosity value.

Furthermore, the value for the carbon residue, Sulphur content and ash content of the Oils are lower than those of Jatropha curcas except for the carbon residue of *Zizyphus abyssinia* that was higher, at 2%. Further, the percent carbon result is in close agreement with those obtained by Kubmarawa *et al.* (2007 and 2011) when they determined the fuel properties of Heeria insignis, Isoberlinia tomentosa and Ceiba pentandra, Isoberlinia doko, and Comniphora kerstingii.

Table 3: Guidelines for Biofuel especially for methyl ester

Countries	Flash Point (^{0}C)	Pour point (^{0}C)	Iodine value	Viscosity mm^2/s
USA 2002	>130	-	NA	1.9-6.0
Europe 2003	>120	-	<120	3.5-5.0
Czech 1998	>110	-	NA	3.5-5.0
Germany 1997	>110	-	<115	3.5-50
Italy 1997	>100	<-15	NA	3.5-5.0
Austria 1997	>100	-	NA	3.5-5.0
France 1997	>100	<-10	<115	3.5-50

NA = not available
http://www.atm.org/cgi-bin/soft Cart-exe/STORE/

The oil of seed of Zizyphus abyssinia, Zizyphus jujube and Olea europeae compared favorably with Jatropha curcas and had fuel properties within the biofuel standards of other countries, Table 3. We concluded that the oil of Zizyphus jujube had the potential to be use as biofuel .However; the researchers did not characterize the fatty acids profile of these oils.

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