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Physical-Chemical Characterization of the Oil Extracted from Sponge Gourd (*Luffa cylindrica*) Seeds and Its Potential Application as Lipid-base Raw Material to Produce Biodiesel

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The escalating prices of petroleum fuels, the uncertainties in their supply and the wreckage of global climate caused by their continual use have rekindled research interests in the use of plant oil for fuels and other biofuels. Sponge gourd seeds were investigated for its biodiesel properties with the aim of determining the desirability of incorporating the oil into bio-fuel. The seeds were sourced for, processed and extracted while the bio-fuel oil obtained were analyzed. 31.0 Percentage (%) of oil yield was obtained from Luffa cylindrica seeds according to American Society for Testing and Materials (ASTM) and Association of Analytical Chemists (AOAC) Standards which were used to determine other Biofuel properties of luffa cylindrica seed. The laboratory analysis revealed that the oil obtained has higher viscosity at 40°C (15.55 mm^2/s) which can perfectly meet up with an established standard of biodiesel on reduction after transesterification. The analysis obtained had a flash point of (150°C), Cetane number of (71.90), Refractive index of (1.645 nm), Acid value of (34.10 mg KOH/g) and Iodine value of (86.20 mgI_2/g) obtained compared with most standard biodiesel which is in agreement with the specified ASTM biodiesel standard.

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1. INTRODUCTION

The need to search for the plant with potential for oil yield necessitate the investigation of the Luffa cylindrica. The need is compelling. Firstly, the population of the world is growing. The growth along with the emergent of economically active and productive population means a continual increase in the demand for food and raw Material (plant oil) for industrial purpose. As the industries continue to expand, it is increasingly competing for the necessary resources (plant oil). Excessive use in one form reduces the amount available for other uses [1]. The increasing low annual rainfall and several draughts in some countries are drastically affecting oil crop production, such as groundnut. one of the promising renewable energy options already exploited by various countries Biodiesel, the fast-growing of petroleum products globally demand for, resulting in decrease of the crude oil reserves in other to adverse environmental concerns and the insecure or unbalance nature of the international market required the need to explore alternative sources of fuel. [2].

Biofuel made from plants could help us reduce our dependency on fossil fuel. Therefore, a growing concern for the future with stack reality striking us at face calls for an urgent need to rectify the situation. The crude fat and crude protein reported by Olaofe et al., [3] were 32.7% and 43.1% respectively. The crude fat composition however, was higher when compared with 23.5% for soybean seed [4], thereby indicating that *Luffa cylindrica* seed is a better source of oil than soybean seed. The crude protein in *Luffa cylindrica* content is 43.1% which is higher when compared with those proteins of rich food such as soybean, cowpea, groundnut, Akee seeds, pigeon peas, and bambora groundnut [3,5], some other oil seed species of cucurbitaceous plants of between 33.13 and 33.25% [6] and gourd seeds of between 23.7 and 30.8% [7]. The *Luffa cylindrica* seed can tolerate low dry zone and intermediate wet zone which are widely used throughout the world. High temperature of between 25°C and 30°C for is required for its germination while the plant prefers sandy loam soil with a pH value ranging between 6.5 and 7.5. Moreover, *Luffa cylindrica* was regarded as weeds and grew in abandoned landscapes without utilization. With search light focuses on its potential as bio-diesel source, it is hoped a confirmed and established potentiality of *Luffa cylindrica* for biodiesel will lead to its cultivation for biodiesel.

2. MATERIALS COLLECTION AND EXPERIMENTAL PROCEDURE

2.1 Experimental Procedure

The *Luffa cylindrica* gourds were obtained from an abandoned building, fence and trees and the seeds were removed as shown in Fig. 1 below. The *Luffa cylindrica* seeds were prepared by opening the dried fruit and removing the seed from Spongy Mesophyll. The seeds were put in an oven at 40°C and were dried for one hour. Thereafter, the dried *Luffa cylindrica* was milled using an electric blender. The seeds were grounded to a coarse texture using a commercial electric blender. 300g of *Luffa cylindrica* seeds milled were fed into a Soxhlet Extractor fitted with a 2-L round bottomed flask. The extraction was executed on a water bath for 6 hours, with n-hexane. The solvent was removed under vacuum, using a rotary evaporator. The amount of oil extracted was determined using the equation below;

$$\%\ \text{Oil Content} = \frac{\text{Weight of oil extracted}}{\text{Weight of the seed}} \times 100 \quad (1)$$

Fig. 1. *Luffa cylindrical* (a) Flower (b) Plant (c) Seed

Source: Ogunyemi et al., [8]

Some the physicochemical properties of the oil extracted were determined using the American Society for Testing and Materials (ASTM) Standards and Association of Analytical Chemists (AOAC) Standards method. The following physical and chemical properties were determined viz: the Colour was determined through visual method. AOAC [9] 'Association of official analytical chemists' official methods of analysis method was adopted in determined the Viscosity, Iodine value and Acid value of the oil using the equations 2, 3 and 4 respectively;

$$\text{Viscosity} = \frac{!\text{Water}}{\text{t water}} - \frac{!\text{Oil}}{\text{t oil}} \quad (2)$$

Where,
! is the Viscosity and
t is the time of flow.

$$\text{Iodine Value (IV)} = \frac{(\text{B}-\text{S})\times\text{M}\times 12.69}{\text{W}} \quad (3)$$

Where,
B is the Blank titre value
S is the Sample titer value; W is the weight of oil.

$$\text{Acid Value} = \frac{\text{V}\times\text{N}\times 56.1}{\text{M}} \quad (4)$$

Where,
V is the Volume of ethanoic KOH used
N is the Molarity of ethanoic KOH used and
M is the weight of oil.

Peroxide value of the oil was determined by using ASTM (D3703) method

$$\text{PV}\ (\frac{mEq}{kg}) = \frac{(\text{S}-\text{B})\times\text{M}\times 1000}{\text{W}} \quad (5)$$

Where,
S is the Sample titre value,
B is Blank titre value, M is molarity and
W is weight of oil.

The equation 6 below using by ASTM (D94) method was adopted for Saponification value of the oil

$$\text{SV} = \frac{(\text{S}-\text{B})\times\text{M}\times 56.1}{\text{W}} \quad (6)$$

Where,
S is the Sample titer value,
B is the blank titer value,
M is the molarity of H_2SO_4 and
W is the molecular weight of KOH.

The cetane number of the oil was calculated via equation 3 and 6 with the use empirical formula (the result of saponification number (SN) and the iodine value (IV) of oil).

$$\text{CN} = 46.3 + \frac{5468}{\text{SV}} - 0.225 \times \text{IV} \quad (7)$$

Where,
SV is the Saponification Value and
IV is the Iodine value.

ASTM (D5006) method was used to determine the Refractive index, and the observed flash points were recorded from the thermometer.

3. RESULTS AND DISCUSSION

The physical and chemical properties of *Luffa cylindrica* seed were respectively presented in Table 1.

The percentage oil yield of *Luffa cylindrica* seed obtained was (31.0%) relatively high in oil content when compared the yield of the oil with that of Soybean (18.35%) (Gunstone, 1999), Amaranthus hybridus (13.95%) [10], and the colour of the oil was found to be dark. Brown as shown in table 1. The Refractive index of the oil extracted from *Luffa cylindrica* seed at 30ºC was (1.645 nm), which is in agreement with the range (1.245 - 1.675) specified in the ASTM biodiesel standard. This is higher when compared to that of sesame seed (1.33nm), coconut seed oil (1.30nm), palm kernel oil (1.40nm) [11], melon seed oil (1.47 nm) and *Moringa oleifera* (1.44 nm) [12]. Which indicate higher purity and saturation.

The kinematic viscosity when compare the value of the kinematic viscosity of *Luffa cylindrica* seed oil which was 15.55 mm^2/s ± 0.01 found to be lower to that of coconut oil 43.30mm^2/s [13], neem oil 44.00 mm^2/s (Sekhar et al., 2009) and Jatropha curcas oil 17.00 mm^2/s [14]. In this experiment, the kinematic viscosity of the biofuel measured at 40^0C had the value of 15.55nm^2/s ± 0.01which does not conform to the ASTM D6751 standard which range between 1.9 – 6.0 mm^2/s at 40^0C. Whereas, the higher the temperature the lower the viscosity this show that biofuel has large molecular mass (Jaichandar and Annamalai 2011). The time imitation of incubating the biofuel samples may led to high deviation from ASTM standard and likely account for the high different in viscosity.

Flash point is an important parameter to be considered in the handling, storage and safety of biodiesel. In this study it was found that the flash point of *Luffa cylindrica* seed oil was higher when compared to that of jatropha oil biodiesel (135°C) but lower than that of palm kernel oil biodiesel (167°C) (Alamu et al., 2008). The flash points of *Luffa cylindrica* seed oil was found to be (150°C) which was above the minimum value (130°C) of the ASTM D93 biodiesel fuel standard and the minimum value (120°C) of the ASTM D6751 biodiesel fuel standard. The relatively higher flash point value of *Luffa cylindrica* seed oil showed that it ensures safe storage and transportation free from hazards.

Cetane number (CN) is widely used as diesel fuel quality parameter related to the ignition delay time and combustion quality. According to ASTM D6751 and ASTM D7170 international biodiesel fuel standards minimum values is 40 and 51 respectively and the value of cetane number of *Luffa cylindrica* seed oil was found to be 71.90, which is well higher than the ASTM D6751 and ASTM D7170 (40 and 51) international biodiesel fuel standards. High cetane numbers help to ensure good cold start properties and minimize the formation of white smoke. This makes it a very good diesel for high-speed diesel engine.

The chemical properties of *Luffa cylindrica* seed were respectively presented in Table 2.

Non-drying oil has iodine value less than 100 [15]. The iodine value of *Luffa cylindrica* seed oil (86.20 mgI_2/g) gotten from this research classify the oil as a non – drying oil. This value is lower than those of corn seed oil (103), sunflower oil (110) and rubber seed oil (134.51) [15], but higher than that of castor oil (83) [15]. The low iodine value of oil is very important due to the fact that heating highly saturated fatty acids results in poor polymerization of glycerides which could reduce rancidity in the oil, makes it possible to preserve the oil and its biodiesel for long period of time. It also reduces the formation of deposits in engines.

The higher the peroxide values of oil, the greater the development of rancidity. Peroxide value of *Luffa cylindrica* seed oil (5.30 meq/kg) showed the oxidative stabilities of the seed oil. According to Oluba et al., [16] reported that low peroxide value of Luffa cylindrica seed oil must have resulted from proper handling of the oil and regulated heat treatment of the oil during extraction since heat favours oxidation of fatty acids thereby increasing the formation of peroxides.

The high acid value of *Luffa cylindrica* seed oil indicates that the oil is non edible, but may be useful for the production of soaps, paints and biodiesel. It would be better converted to biodiesel using the two stages process of esterification and transesterification to reduce the formation of soap. The acid value of *Luffa cylindrica* seed oil was 34.10 mgKOH/g. which was higher than those of soybean oil (2.67 mgKOH/g), rape seed oil (2.88 mgKOH/g) (Jordanov et al., 2007), palm oil (3.8 mgKOH/g) [17] and Brachystegia eurycoma (27.08 mgKOH/g) (Ibeto et al., 2008). And well above the ASTM biofuel standard 0.5 mgKOH/g. The high acid value of *Luffa cylindrica* seed oil suggests presence of high levels of hydrolytic and lipolytic activities in the oils.

The saponification value obtained for *Luffa cylindrica* seed oil (165.40 mgKOH/g). Higher than that of Pumkin Seed oil (44.88 mgKOH/g), African bean oil (28.05 mgKOH/g) and Sesame oil (98.56 mgKOH/g) [11]. indicates the presence of high percentage of free fatty acids in the oil and therefore, implies the possible tendency to soap formation but lower than those of common seeds such as, linseed oil (195 mgKOH/g) (Singh and Siroj, 2009), and 257mgKOH/g for coconut [18]. If utilized for biodiesel production there will be difficult in separation of the product due to high value obtained from the luffa cylindrica seed oil but can be trans esterification to reduce the formation of soap.

Table 1. Physical properties of *Luffa cylindrica* seed oil

Parameters	Results
Colour	Dark brown
Refractive index (nm)	1.65 ± 0.00
Kinematic viscosity(nm^2/s) at 40°C	15.55 ± 0.01
Flash point	150°C
Cetane number	71.90

Table 2. Chemical properties of *Luffa cylindrica* seed oil

Parameters	Result
Iodine value (mgI_2/g)	86.20 ± 0.00
Peroxide value (meq/kg)	5.30 ± 0.01
Acid value (mg KOH/g)	34.10 ± 0.00
Saponification value (mgKOH/g)	165.40 0.01

4. CONCLUSIONS

From the report of the study, it is concluded as follows:

The percentage oil yield of *Luffa cylindrica* seed obtained was (31.0%) relatively high in oil content. colour is dark brown, refractive index of the oil extracted from the seed at 30°C was 1.645nm. the kinematic viscosity of the biofuel measured at 40^{0}C had the value of 15.55 nm^2/s ± 0.01which does not conform with the ASTM D6751 standard which range between 1.9 – 6.0 mm^2/s at 40^{0}C. The flash point of *Luffa cylindrica* was 150°C. It is safe for storage and free from transportation hazard. Cetane number was 71.90. It is therefore a good biodiesel for high diesel engine. The iodine value of *Luffa cylindrica* oil is 86.20 MgI_2/g. mean the oil is non-drying oil and low iodine value of *Luffa cylindrica* seed oil can be used to reduce the formation of deposits in engine, the rancidity of the oil and its biodiesel can be preserving for long period. The peroxide value of *Luffa cylindrica* seed oil was 5.30 meq/kg. The saponification value of the oil was 165.40 mg KOH/g. due the presence of high free fatty acid in its oil which implied the possible tendency to soap formation which can be reduce by transesterification.

Finally, the biofuel properties investigated had shown to a reasonable extent that quality biodiesel can be produced from the *Luffa cylindrica* seeds.

5. RECOMMENDATION

The followings were recommended and further research should be carried out on:

i. The kinematic viscosity of the biofuel measured at 40^{0}C had the value of 15.55 nm^2/s ± 0.01 which does not conform to the ASTM D6751 standard which range between 1.9 – 6.0 mm^2/s at 40^{0}C. The of *Luffa cylindrica* seed oil.
ii. Low iodine value of *Luffa cylindrica* seed oil can be used to reduce the formation of deposits in engine, the rancidity of the oil and its biodiesel can be preserving for long period.
iii. The high value of saponification obtained from the *Luffa cylindrica* seed oil which indicated presence of high free fatty acid in the oil therefore it can be transesterification to reduce the formation of soap.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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