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Physicochemical Analysis and Biodiesel Potential of Bottle Gourd (Lagenaria Siceraria) Seed Oils

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ABSTRACT
Lagenaria siceraria commonly known as bottle gourd or calabash, is a versatile plant species that has been widely cultivated for its edible fruit and various other uses. In this study, the physicochemical properties of Lagenaria siceraria oil were investigated to evaluate its potential and industrial applications. The oil was extracted from the seeds of Lagenaria siceraria using a soxhlet extraction method, and its physicochemical parameters, including percentage yield, acid value, peroxide value, saponification value, iodine value, and fatty acid composition, were determined. The results revealed that Lagenaria siceraria oil had a low moisture content, indicating its good storage stability. The acid value and peroxide value were found to be within acceptable limits, suggesting that the oil had low levels of free fatty acids and oxidative rancidity. The saponification value indicated the average molecular weight of the oil, while the iodine value reflected its unsaturation degree. These parameters are crucial for determining the oil's suitability for various industrial applications. Furthermore, gas chromatography-mass spectrometry (GC-MS) analysis of the fatty acid composition demonstrated that Lagenaria siceraria oil primarily consisted of unsaturated fatty acids, with linoleic acid (C18:2) and oleic acid (C18:1) being the major components. The presence of these essential fatty acids suggests that Lagenaria siceraria oil can be used for biodiesel production.

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INTRODUCTION

Bottle gourd (Lagenaria siceraria) is a pan tropic plant and displays variation of fruit and seed shape. Bottle gourd native to Africa (tropical Africa) and the genus lagenaria contains six species, five of which are wild; L.abysinica (Hook.f.) C. Jeffrey, L.bleviflora (Benth) Roberty, L.guineensis (G. don) C. Jeffrey, L. rufa (Gilg) C. Jeffrey, and L. Sphaerica (Sonder) Naudin (Essien et al., 2013a;Schlumbaum et al., 2012). Lagenaria Siceraria native of Africa of family Cucurbitaceae is an annual herbaceous plant, with a height ranging from 18-24 inches. It has a circular leaf shape and an annual climbing vine, its edible and pollination is self-type (Chimonyo and Modi, 2013).

The study of Biodiesel production from oil plants like Lagenaria siceraria is very timely because of arising problems such as the rising cost of fuel in the market, global warming phenomenon, and health problems such as respiratory diseases caused by the harmful byproducts of burning petroleum-based fuels. Another problem concerning the use of diesel is the deteriorating effects of the increased amount of Greenhouse Gases in the atmosphere.

The term oil is used in generic sense to describe all substances that are greasy or oily fluid at room temperature (Buba, 2005). Generally, fats are considered as extracted triglycerides/lipids that are liquid under the same condition. Fats and oils belong to a larger group of naturally occurring substances called lipids. Because lipids serve as a convenient means of rapid heat transfer, they have found increasing use in commercial frying operations (Sadrolhosseini, et al., 2011).

Fats and oils are non-volatile substance insoluble in water but soluble in organic solvent. They constitute along with protein and carbohydrates, the major food stuffs and are widely distributed in nature. From chemical point of view, oils and fats are products of the reaction between a triol (glycerol) and three molecules of fatty acids.

This type of reaction is commonly termed as esterification. Oils/fats are obtained basically from two sources namely: animal and vegetable sources (Sadrolhosseini, et al., 2011). Animal fats and oils are derived both from terrestrial and marine animals. Marine fats include liver oils etc. Terrestrial fats and oils derived from animals include lard (from Swine), suet (from oxen or sheep), ghee (from cow or buffalo milk), etc. Vegetable oil is found in greatest abundance in fruits and seeds.

Oils obtained from plant source are termed vegetable oils. These include: palm oil, cotton seed oil, ground oil, sunflower oil etc. Non-edible oils from plant sources are of interest in various industrial applications and industries (Muhammad et al., 2014).

Biodiesel, which is accepted as an attractive alternative fuel, is prepared by transesterification of vegetable oils and animal fats with an alcohol in the presence of a catalyst. However, the land use for production of edible oil for biodiesel feedstock competes with the use of land for food production. Moreover, the price of edible plant and vegetable oils is usually higher than petrodiesel. The use of waste cooking and non edible oil as biodiesel feedstock reduces the cost of biodiesel production. A huge amount of waste cooking oil generated from the

restaurant and food process industries is disposed without prior treatment (Mindora et al., 2010).

Biodiesel can be define as the mono-alkyl esters of fatty acids derived from lipids (vegetable oils or animal fats) (Muhammad et al., 2014). As reported by Muhammad et al., (2014) biodiesel possesses certain advantages over conventional fossil diesel especially in terms of lesser emission of harmful gasses and particulates. It was reported by Baik et al., (2005) that the use of biodiesel instead of petro diesel or in blended form in diesel engine showed reduced levels of exhaust emissions of CO and PM. Biodiesel burns clean, this means there will be reduction on all type of pollutants adding to smog and global warming (Mindora et al., 2010).

LITERATURE REVIEW

The study of Biodiesel production from oil plants like Lagenaria siceraria is very timely because of arising problems such as the rising cost of fuel in the market, global warming phenomenon, and health problems such as respiratory diseases caused by the harmful byproducts of burning petroleum-based fuels. Another problem concerning the use of diesel is the deteriorating effects of the increased amount of Greenhouse Gases in the atmosphere.The term oil is used in generic sense to describe all substances that are greasy or oily fluid at room temperature (Buba, 2005). Generally, fats are considered as extracted triglycerides/lipids that are liquid under the same condition. Fats and oils belong to a larger group of naturally occurring substances called lipids. Because lipids serve as a convenient means of rapid heat transfer, they have found increasing use in commercial frying operations (Sadrolhosseini, et al., 2011).

METHODOLOGY

Oil Extraction

Thirty grams (30g) of powdered lagenaria siceraria was placed in the thimble and 150 cm3 of n-hexane was poured into the round bottom flask. The apparatus was heated at 600C for 6 hrs of continuous extraction using soxhlet apparatus. The experiment was repeated for the same weights of the sample. The solvent was recovered by assembling the apparatus. Remnant solvent in the oil was removed using rotary evaporator. Oil yield was calculated using equation 1

$$\%Oil\ Yield\ = \frac{Weight\ of\ extracted\ oil(g)\ x\ 100}{Weight\ of\ sample(g)}$$

Determination of Acid Value of the Oil

Method describe by Adepoju et al., (2013) was use for this determination. Two (2g) of the oil sample was weighed and transferred into a conical flask to which propan-2-ol (50cm3) was added. The content was titrated against 0.1M KOH using phenolphthalein indicator until it changes to pink colour. Acid value was calculated and recorded using equation 2

$$Acid\ Value\ = \frac{56.1xVxM}{W}$$

V= Volume of KOH used (cm3), M= Molarity of KOH (0.1M), W= Weight of oil sample (g), 56.1= Molecular weight of KOH (g)

Determination of Saponification Value

Method describe by Jagadale and Jugulkar (2012) was use for this determination. Two (2g) of the sample was weighed into a conical flask and ethanolic potassium hydroxide (25cm3, 0.1M) was added. The conical flask containing the mixture was connected to a reflux condenser and heated for five minutes with occasional shaking to ensure complete dissolution of oil. The mixture was allowed to cool and slowly titrated against hydrochloric acid HCl (0.5M) using phenolphthalein indicator until the colour changes from purple to colourless. Saponification value was calculated by using equation 3

$$Saponification\ Value\ = \frac{56.1N(V0 - V1)}{M}$$

Vo = The volume of HCl used for the blank titration, V1 = The volume of the solution used for the determination, 56.1 = Molar mass of KOH (g), N = Normality of HCl used, M = Mass of the sample

Determination of Ester Value

This was done in accordance with procedure reported by Gafar et al., 2012. Ester value = Saponification value – Acid value

Determination Iodine Value

Method describe by Jagadale and Jugulkar (2012) was use for this determination. A measured quantity of oil (0.5g) sample was weighed into the conical flask (250cm3), acetic acid (10cm3,) was added and the mixture stirred until the oil sample completely dissolved in the acid. Iodine monochloride (20cm3) was added to the mixture and stirred, then incubated in the dark for thirty (30) minutes. Potassium Iodide solution was later added to the mixture. The mixture was titrated against standardized sodium thiosulphate (0.5M) until pale straw colour is observed. Starch indicator (2cm3) was added to the content, a purple colour is observed. The titration was carried on until the colour of the solution turns colourless, the disappearance of the colour was recorded as end point. The procedure was repeated for the blank titration.

$$Iodine\ Value\ = \frac{56.1N(Vb - Va)x6.2025}{W}$$

Va = Titre value for Na2S2O3 used in the test titration (cm3), Vb = Titre value of Na2S2O3 used in the blank titration (cm3), W = Weight of oil (g), 6.2025 = mass of the Na2S2O3 in a 250cm3 solution.

RESULTS AND DISCUSSION

Steps of Your result test here

In this section, you must provide us with each step taken to accomplish your studies. You must not put too much the result of descriptive statistics here; on the other hand, it should be summarized in an easier to read table or graphs. You must not forget the numbers for every table and chart presented in your paper.

Physicochemical Properties of Lagenaria Siceraria Oil

Table 1. Physicochemical Properties of the Lagenaria Siceraria Oil Extracted

Physicochemical Properties of *Lagenaria Siceraria* Seed oil	
Parameter	**Observed Values**
% oil Yield	42.30 ± 0.418
Saponification Value (mgKOH/g)	209.91±0.468
Iodine Value (g/100g)	100.38±0.179
Acid Value (mg/KOH)	1.55±0.054
Ester Value	208.415±0.132
Specific Gravity	0.917±0.005
Viscosity (mm^2/S)	3.56±0.043
% Impurity	0.735±1.020
Odour	Pleasant
Colour	Light yellow
%FFA	0.778±0.027

Values are mean standard deviation of triplicate determination.

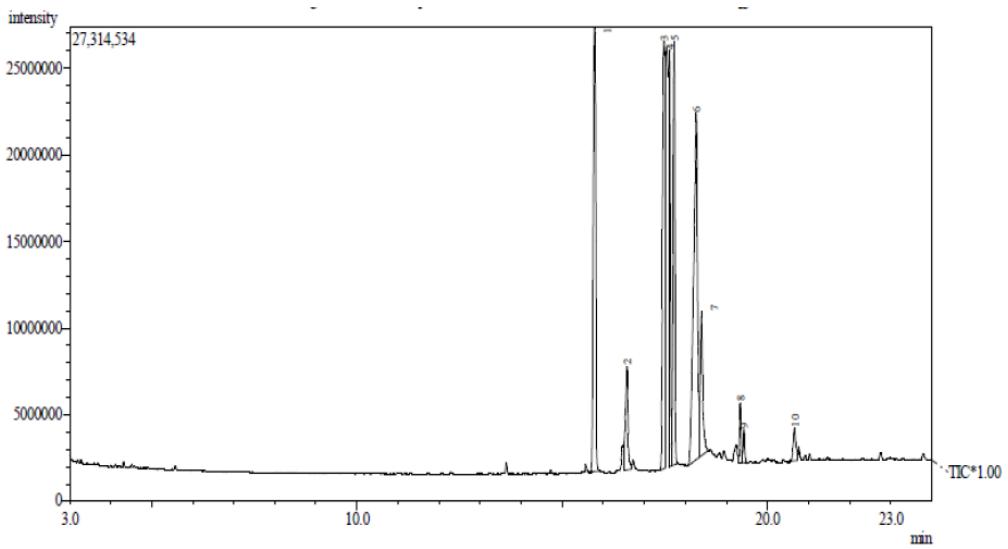

Figure 1. GC-MS Chromatogram of Hexane Extract of Lagenaria Siceraria

Percentage Oil Yield

The oil yield of 42.30% signifies that the seed contains remarkable oil content. Although it's a bit lower than 44.85% for Lagenaria siceraria reported by Fokou et al., (2009) and (45% obtained by Chimonyo and Modi (2013), the value agrees with that of Essien et al., 2013a (42%). The difference in oil yield could be attributed to variation in genes, climate, plant species, soil condition and extraction techniques such as prolong exposure of harvested seeds to sunlight which is capable of impairing the oil yield considerably (Fokou et al., 2009; Raja et al, 2011).

Comparing the oil yield with known vegetable oil of plant origin like Cotton seeds (18%) reported by Akbar et al., 2009, Chrysophyllum albidum (15%) reported by Adelola et al., 2012, Shea butter (16.85%) reported by Umaru et al., 2013, soybean (34%) reported by Kyari, 2008, Pearsea americana (18%) (Akbar et al., 2009), Detarium microcarpum (1.8%) reported by (Kyari, 2008), and Mango (7.42%) (Sam et al., 2008), (40.10%) (Abubakar et al., 2014) and (13%) (Nzikou et al., 2011). However, the yield seems to be low when compared with Onion seed oil (50.28%) (Warra et al., 2015) Jatropha seed (64.4%) (Adebowole and Adedine, 2006), Melon seed (53.20%) (Abubakar et al., 2014), Sweet orange seed (43.10%) (Abubakar et al., 2014).

Acid Value

The acid value (AV) of oil indicates the contents of free fatty acid in the oil sample and it's an important parameter that influences shelf life of the oil (Alhassan et al., 2015; Predojevic, 2008, Warra et al., 2013). The AV of Lagenaria siceraria obtained is 1.55 mg KOH/g and is lower than the one reported in the literature 5.21 mg KOH/g (Aremu et al., 2010). It is also lower than 3.51mgKOH/g reported by Essien et al., 2013b, it is also lower compared to other species of Lagenaria Siceraria i.e. 2.1 mgKOH/g (speckled swan gourd), 2.4 mgKOH/g (bird house gourd) as reported by Essien et al., (2013b).

The oil will not be as corrosive as paw-paw which have acid value of 47.12 mgKOH/g as reported by Okoye and Ibeto, (2010).The low AV value also signifies that the oil may be edible because its less than 10 (Aremu et al., 2015). Low AV favours the choice of oil for biodiesel production, production of paints, liquid soap and shampoo (Aremu et al., 2006b; Predojevic, 2008). The low level of free fatty acids in the oils suggests low levels of hydrolytic and lipolytic activities in the oil. (Akanni et al., 2005; Gordon et al., 1993). Appreciable acid value of oils is an indication that the plant might be poisonous for livestock (Aremu et al., 2006a, Aremu et al., 2012, Aremu et al., 2015).

Saponification Value

The SV of the lagenaria siceraria oil was found to be 209.91±0.468 mgKOH/g. If a fat has low saponification value, chain length of the fatty acid will be long. Triglycerides with long fatty acids have more mass. Also, the long chain fatty acids have a relatively fewer number of carboxylic functional groups per unit mass of the fat and therefore high molecular weight (Akanni et al., 2005).

As the mass increases, the saponification number decreases (an inverse relationship). So a given mass of a triglyceride will have a larger number of moles at low molecular weight than high, and accordingly consume a larger number of

moles KOH. The oil may have potential for use in soap making and cosmetic industry and for thermal stabilization of poly vinyl chloride (PVC) (Akanni et al., 2005).

However, the value is within the range of edible oils as reported by Eromosele et al., (1994). The value is lower than 221.00mgKOH/g, and 225.10mgKOH/g reported for white and yellow bottle gourd (Aremu et al., 2010), and 244.2mgKOH/g for (tobacco box) reported by Essien et al., (2013a). In the same vein values reported by Essien et al., (2013b), 221.6mgKOH/g and 244.2 mgKOH/g for speckled worm and bird house gourd were a bit higher. However, the value appreciates against those reported by Essien et al., (2013b), 197.75mgKOH/g for (long handle dipper), and 192mgKOH/g for Garlic (Allium sativum) reported by Gafar et al., (2012). Variations in SV of the Lagenaria siceraria could be attributed to the variation in the nature of cultivars (species).

Iodine Value

The iodine value is a measure of the degree of unsaturation and it is an identity characteristic of seed oils making it an excellent raw material for soaps cosmetics industries (Essien et al.,2013a). Iodine value could be used to quantify the amount of double bond present in the oil which reflects the susceptibility of the oil to oxidation. The iodine value of lagenaria siceraria was found to be 100.38 which does not agrees with the results 129.60mg/100g reported by Essien et al., (2013a).Comparing the iodine value obtained for lagenaria siceraria and other vegetable oils reported in the literatures, the value appreciates against that of star apple 35mg/100g (Adebayo et al., 2012), 90g/100g, 80g/100g, 94g/100g, 67g/100g76.4g/100g for cotton seed oil, peanut kernel, rapeseed oil, African star apple, and mango seed oil respectively, (Agbede et al., 2011).

The oil from lagenaria siceraria oil is nondrying, and the IV according to EN 14214 (European committee for standardization) should be less than 120g I2/100g sample for the seed oil to be suitable as feedstock for biodiesel production (Audu et al., 2013).

Percentage Free Fatty Acid

This is the percentage by weight of a specified fatty acid (e.g. percent oleic acid) (Aremu et al., 2010; Musa et al., 2015). High concentration of free fatty acid results in large losses of the neutral oil during refining, high level of free fatty acid are undesirable in finished oils because they can cause off-flavours and shorten the shelf life of oils. It's the measure or indicator of the overall quality of oil from the results obtained the FFA of lagenaria siceraria is 0.778%mg/KOH and is lower than that reported by Essien et al., (2013a) 2.60mg/KOH and 2.30mg/KOH for white and yellow bottle gourd respectively, the variation in the values could be attributed to poor processing technique or long term storage (Adepoju and Olawole 2014).

Table 2. GC-MS Profile Chromatogram of Lagenaria Siceraria

S/N Name of fatty acid	MF	MW	RI	SI to STC
1. Palmitic acid	C16H32O2	256	1968	93
2. Stearic acid	C18H36O2	284	2167	90
3. Eicosadenoic	C21H38O2	322	2292	90
4. Linoleic acid	C19H34O2	294	2093	89
5. Oleic acid	C18H34O2	282	2175	93
6. Erucic acid	C22H42O2	338	2572	90
7. Arachidic acid	C20H40O2	312	2366	86
8. Behenic acid	C23H46O2	354	2475	89

S/N = Serial number, M.F.=Molecular formula, M.W. = Molecular weight, RI= Retention index SI% = Similarity index, T.C. = Target compound.

CONCLUSIONS

This study has demonstrated the possibility of producing biodiesel from lagenaria siceraria seed oil. Oil yield content of the seed using soxhlet apparatus was 42.7 based on the physicochemical properties of oil observed, the oil is suitable not only for biodiesel Production but also for paints, cosmetics. It's also suitable for making candles and lubricating oils.commercial and industrial extraction of the oil for the purpose of fuel production is possible, and on a laboratory scale soxhlet extraction proves to be the best and effective method.

FURTHER STUDY

Every research is subject to limitations; thus, you can explain them here and briefly provide suggestions to further investigations.

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