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Assessment of Properties of Biodiesels Produced from Degummed and Undegummed Oil Fractions of *Luffa cylindrica* (Linn.) Seeds

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ABSTRACT
Biodiesel is one of the renewable energy sources that has emerged as an alternative means to conventional diesel. Therefore, search for non-edible oil for biodiesel production is required for sustainable biodiesel production. This study aimed to evaluate the physicochemical properties of biodiesels produced from degummed and undegummed oil extracted from dried seeds of *Luffa cylindrica* using Soxhlet extraction protocol. The extracted oil was divided into two portions; one portion was subjected to ionic degumming using 300 µg/mL of NaCl, while the other portion was left un-degummed. The two portions were, in turn, subjected to transesterification using high purity methanol. Results of the physicochemical properties of the resultant biodiesels indicated that degummed oil produced a better biodiesel yield (79 to 95%), with a change in flash points from 160 ℃ to 150 ℃, decreased pour points from 3.9℃ to 2.1 ℃, and increased Cetane number from 43.97 to 68.76. Also, reductions in iodine value from 35.00 mgI_2/100 g to 15.00 mgI_2/100 g, peroxide value from 10 meq/kg to 6 meq/kg, free fatty acid from 1.15 to 0.88 and acid value from 0.92±0.12 to 0.32±0.04. The study concluded that degummed oil from *Luffa cylindrica* could serve as an excellent feedstock for biodiesel production.

Keywords:
Degumming,
Biodiesel,
Luffa cylindrica,
Fuel properties and
Transesterification.

INTRODUCTION

Demand for energy has been on the increase for the past several decades due to energy consumption for production purposes in industries. The bulk of this energy demand was on fossil fuel. The main challenge on the demands for energy from fossil fuel is its possible depletion from reservoirs and negative environmental impacts of the combustion byproducts such as high level of noxious gases and particulate matters generated during incomplete combustion of the internal combustion engine. These gases and particles have been implicated as part of substances responsible for climate change and ozone layer depletion (Khethiwe *et al*., 2020**)**.

Continuous sourcing for renewable energy has become a strongly promising alternative to overcome global energy challenges more so that such alternative energy resources are known to be more eco-friendly (Bhuiyan, 2022). According to Olabi *et al.* (2023), the demands for biofuel, which is one of the alternative fuels to fossil fuel, gained traction from 29.29% in the year 2000 to 126.65% in the year 2020. This was intended to shift attention from fossil fuel and reduce carbon footprint and other greenhouse gas emissions. Bio-ethanol and biodiesel have become an alternative to conventional fuels in compression-ignition internal combustion engines (Adekunle *et al*., 2016). The idea of using vegetable oils as alternative fuels occurred from the same pioneer of Rudolph Diesel who successfully trailed peanut oil in his revolutionary compression-ignition engine over a century ago. Biodiesel is obtained from resources that are renewable; as such, it presents environmental benefits, including lower emission and toxicity in comparison with petroleum diesel. Besides, biofuels, compared to the current regular conventional fuels, are readily biodegradable; they and their feedstocks degrade as quickly as sugar (Torkashvand *et al*., 2022).

Transesterification is the main process for transforming virgin or waste cooking oil to biodiesel. The reaction involves triglycerides, the major molecular components of animal fat and vegetable oil combining with an

alcohol such as methanol being often used with KOH as a catalyst. In this reaction, two products are obtained: fatty acid methyl esters, or biodiesel, and glycerol, which is a co-product of great value (Long *et al*., 2021). Triglycerides, which is the chemical composition of vegetable oils, builds a perfect substrate for a transesterification reaction (Salaheldeen *et al*., 2021). This chemical compatibility is the main reason for vegetable oil widespread use as main feedstock in biodiesel production. The efficiency of this conversion process influences directly the economic viability and environmental benefits that biodiesel offers as a substitute fuel (Ahmed, 2021).

While edible oils such as soybean, canola, and palm oils have traditionally been used in large volumes for biodiesel production, their extensive use has raised significant food security and economic concerns, which are usually encapsulated into what is variously termed the "food versus fuel" dilemma (Das and Gundimeda, 2022). Diversion of food crops or edible oils for energy could create unwanted impacts such as increased prices of food along with possible shortages and reduction of food security in countries that depend highly on these products. This thus calls for the exploration of non-edible feedstocks to advance sustainability concerns and enhance the biofuel industry on ethical and more resilient grounds.

There is high interest globally in exploring non-edible oil feedstocks (Sanni *et al*., 2018). Among the promising sources of non-edible oils include *Luffa cylindrica* plant which is popularly known as smooth Luffa or sponge gourd. It belongs to the Cucurbitaceous family. The fruit of the plant which contain numerous seeds and cucumber-like in appearance is green at early stage, becomes yellow and then finally brown when dried. The cucumber-like internal structure becomes network of fibre with minimum of 30 black seeds inside the network (Akinwunmi *et al*., 2021). This plant is mainly grown for its mature, fibrous fruits, which are used to make biodegradable sponges by a number of personal care and cleaning industries. The oil content of *Luffa cylindrica* seed is between 45-51% with monounsaturated Oleic and polyunsaturated Linoleic acids as the main fatty acids content (Onigemo *et al*., 2020).

The crude vegetable oils, regardless of their origin, contain various undesirable impurities, including phospholipids (commonly referred to as gums), free fatty acids (FFAs), proteins, peroxides, oxidized fatty acids, pigments and several other impurities (Gharby, 2022). The presence of these impurities can severely compromise the efficiency, yield, and overall quality of the biodiesel production process. For example, high concentrations of FFAs can react adversely with the alkaline catalysts commonly employed in transesterification, leading to the undesirable formation of soap (Ahmed, 2021). When soap is formed, both biodiesel yield and efficiency of the process decrease, and the soap formation further complicates the subsequent separation of the biodiesel and glycerol phases (Azmi *et al*., 2025). The presence of phospholipids and other gum-like substances are of great concern because they can deactivate the catalyst, leading to reduction of the conversion of triglycerides to methyl esters. Hence, degumming crude oil (extracted vegetable oil without further treatment) is pivotal to efficient biodiesel production (Sharma *et al*., 2019). Degumming is an important process in the vegetable oil refining process which helps to drastically reduce gums that are present in the crude oil, lessens separation challenges, and facilitates the optimization of the biodiesel production process. It is specifically designed to eliminate phospholipids and other gum-like impurities from the crude oil. This pre-treatment is essential to improve the overall oil quality and to minimize refining losses.

This study therefore was aimed at determining the effect of degumming on the physiochemical and biodiesel properties of *Luffa cylindrica* seed oil in comparison to standard fuel properties.

MATERIALS AND METHODS

Sample collection and preparation

The ripe pods of *Luffa cylindrica* were harvested within the campus of the Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. The plant with the pod was identified at the IFE HERBARIUM in the Department of Botany,(**IFE, 18630**) Obafemi Awolowo University, Ile-Ife, Nigeria. The dried pods were opened up manually and the seeds were obtained by cutting the spongy covering to ease the removal of the needed seeds. These seeds were sun-dried for one week to ease manual decortication which was done to separate the white melon-like seeds from the black shells. The decorticated seeds were further sun-dried for another period of one week to reduce the water content and aid effective seed grinding using a blender.

Oil extraction.

Soxhlet extraction method (AOCS, 2004) was used to extract oil from the grounded seed sample. Per time, 20 g portion of the grounded sample was placed in a cellulose thimble pre-washed with acetone/n-hexane mixture and oven dried at 70 °C for 2 hours. The oil was then extracted with n-hexane for approximately 6 hours. The resulting oil extract was concentrated by removing the solvent through distillation so as to yield a solvent-free crude oil. To ensure complete solvent removal, the oven was set at 70 °C and the flask containing the oil flask was placed in it. Before degumming, the solvent-free crude oil was preserved in an air-tight container placed under a cool cupboard with very limited light penetration.

Oil Degumming.

For the oil degumming, the method developed by Oyekunle *et al*. (2013) was used. Five millilitres (5 mL) of raw oil was measured carefully and mixed with 1 mL of a 300 µg/mL NaCl solution. The mixture was then stirred for 1 hour at 60 °C using a magnetic stirrer, causing the phosphatides that are already dissolved in the oil to become insoluble. Centrifugation at 1000 rpm for 30 minutes separated the insoluble phosphatides. During stirring, a waxy mixture was formed beneath the oil layer, believed to be a complex of fat-dissolvable impurities originally available in the oil. To separate the two layers, the supernatant oil layer was decanted from the waxy mixture.

Transesterification.

Transesterification of the vegetable oil was performed using methanol while KOH was employed as the catalyst, following the method described by Van Gerpen *et al*. (2004). The reaction conditions included a 6:1 methanol-to-oil molar ratio, one percent catalyst concentration, and a temperature of 65 °C. In a 250 mL flat-bottom flask equipped with a condenser, 100 g of oil was accurately weighed and pre-heated for 30 minutes to enhance its reactivity with methanol. In a separate beaker, one percent (1%) KOH (by weight of oil) was dissolved in 21.7 g of methanol to form potassium methoxide. This solution was then added to the pre-heated oil and stirred for 2 hours using a magnetic stirrer. After the reaction, the mixture was transferred to a separating funnel and allowed to settle for 12 hours, resulting in two distinct phases: glycerol at the bottom and methylester at the top (Van *et al.*, 2004). Base catalyzed transesterification was employed because of its great conversion efficiency that can be achieved within shorter timeframes compared to acid-catalyzed processes (Fukuda *et al*., 2001; Lotero *et al*., 2005).

The percentage conversion of the oil to biodiesel was calculated as:

$$\% \text{ conversion} = \frac{Mass\ of\ biodiesel\ produced}{Mass\ of\ oil\ used} \times 100$$

The physicochemical and biodiesel properties of the biodiesel produced from both raw and degummed oil of *Luffa cylindrica* seeds determined are kinematic viscosity, flash point, pour point, cloud point, smoke point, cetane number, higher heating value, and heating efficiency, all of which were determined following the methods described by the American Society for Test and Material (ASTM) (ASTM D664-19), (ASTM D93-20) and (ASTM D97-20).

RESULTS AND DISCUSSION.

Percentage oil composition and biodiesel yield

The oil content of *Luffa cylindrica* seed in this study was found to be 31.61±1.58% and was comparable with previous reports by earlier researchers (Abitogun and Olumayede, 2005; Abitogun and Asogbon, 2010; Ogunyemi *et al*., 2020; Tyagi *et al*., 2023), with values ranging from 29.77% to 33.93%. In comparison, the oil content was higher than the range (14.05 - 20.30%) reported for conventional oil seeds like soybean, locust bean, and cotton oil seed (Ayodele *et al*., 2000). Also, the oil content of the seed compared favourably well with the 26 - 42% oil yield range of seeds considered by Kyari (2008) to be reasonable oil yield. According to Table 1, the biodiesel yield of the un-degummed oil was 79% while that of degummed oil was 95% with a difference of 16%. The difference observed in the percentage biodiesel yield between the un-degummed and degummed oil of the seed is an indication that degumming process improved biodiesel yield. The presence of certain components of vegetable oil such as phospholipids, metals and gummy materials capable of hindering the transesterification process were removed during the process of degumming. Among other effects, these components are capable of deactivating the catalyst, impeding glycerol phase separation, and causing carbon particle deposition in engine machinery, which ultimately affects engine performance (Sharma *et al*., 2019).

Acid value

Oil acid value serves as an important measure for evaluating the quality of the oil, specifically assessing the levels of free fatty acids generated through lipolytic enzyme hydrolysis and oxidative processes. Acid value quantifies residual un-reacted acids in refined fuels. A low acid value is a strong indicator of oil stability, suggesting enhanced resistance to degradation, peroxidation, and rancidity, thereby ensuring prolonged shelf life (Aremu *et al.*, 2015).

In the present study, the acid value of raw (unrefined) oil from *Luffa cylindrica* was found to be 32.41 mg KOH/g. This value was lower than the previously reported values of 34.15 mg KOH/g (Ozulu, 2015) and 68.88 mg KOH/g (Aremu and Amos, 2010). Biodiesel production and degumming significantly further reduced the acid values; the acid value of biodiesel obtained from raw oil was 0.92 mg KOH/g, while that of biodiesel from degummed oil was 0.32 mg KOH/g (Figure 1). The acid value reduction could partly be attributed to the ability of the base catalyst to remove free fatty acids during biodiesel production (Adekunle *et al.*, 2016). This reduction suggested enhanced refining and purification processes, culminating in a high-quality biodiesel product. In particular, the drastic decrease in the acid value of the degummed oil biodiesel suggested that the biodiesel would not cause a predisposition of the engine to high corrosion levels. In addition, the acid value (0.32

mg KOH/g) of the degummed biodiesel conformed to the 0.8 mg KOH/g ASTM standard.

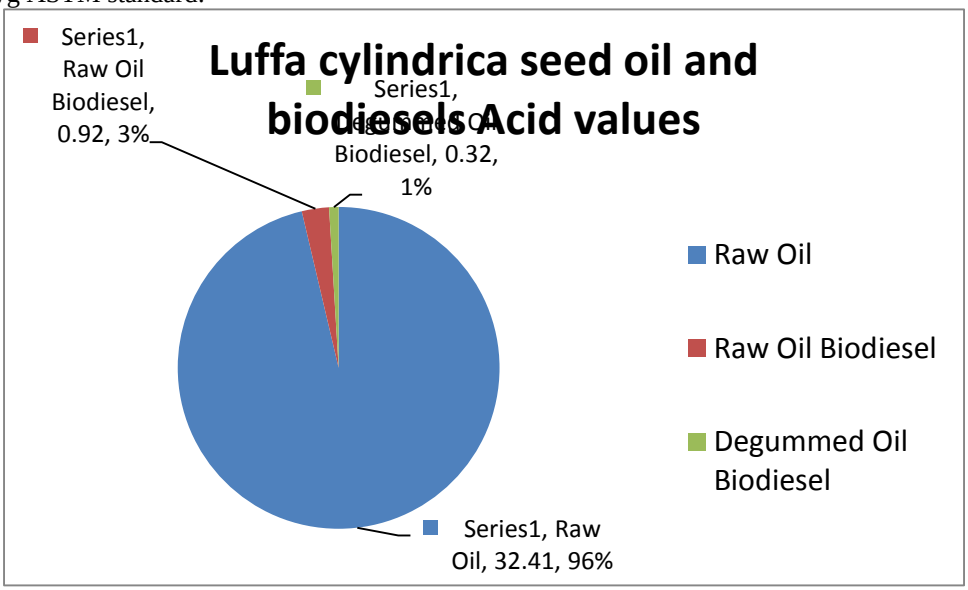


Figure 1: Acid values (mg KOH/g)

Saponification Value

The saponification value of the oil extracted from *Luffa cylindrica* seed was 140.25 mgKOH/g (Figure 2). This provides some insight into the average molecular weight of the triacylglycerol constituents of the oil. Comparing the result with the ones in literature, the value was significantly lower ($p < 0.05$) than the saponification values (mgKOH/g) obtained by Oyekunle and Omode (2008) for seed oils of *Cucumeropsis edulis* (207.1), *Hevea brasiliensis* (203.4), *Hura crepitans* (202.0), *Jatropha curcas* (206.6), *Khaya ivorensis* (210.4) and *Citrus sinensisi* (208.5). It was also lower than those reported by Eze (2012) for oils of *Psophocarpus tetragonolobus* (190.34 mgKOH/g), sheanut (195 mgKOH/g), and *Jatropha* (193.55 mgKOH/g) oils, yet higher than Pumpkin seed (44.88 mgKOH/g), African bean (28.05 mgKOH/g), and sesame (98.56 mgKOH/g) oils. High saponification value is an indication of a high percentage of fatty acids, which could potentially lead to soap formation and separation difficulties in biodiesel production, as well as low methyl ester yields. In the present study, transesterification and degumming effectively reduced the saponification value to 80 mgKOH/g making the saponification value obtained to fall within the acceptable range of 191-202 mgKOH/g of ASTM standard (Kipkoech and Takase, 2023).

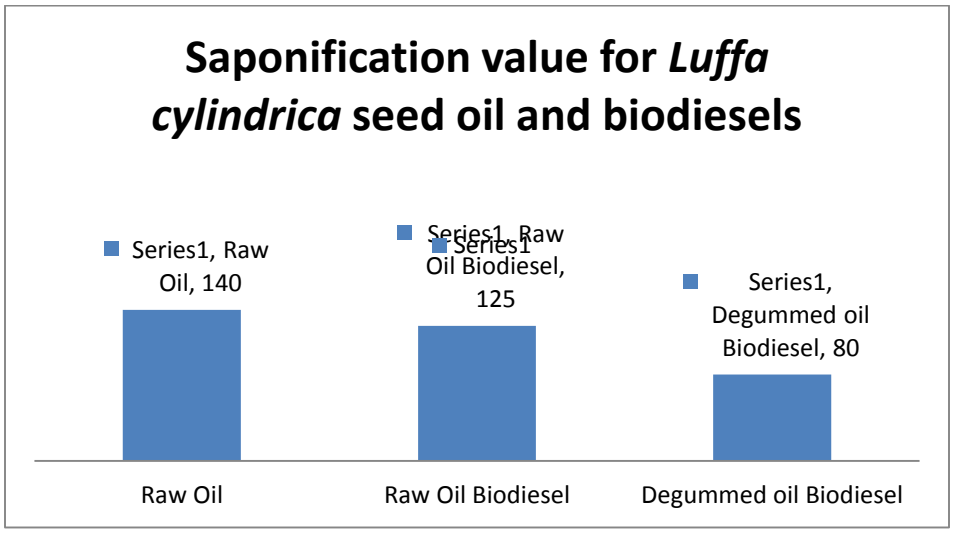


Figure 2: Saponification value (mg KOH/g)

Iodine Value

In the determination of the level of unsaturation in lipids (fats and oils), iodine value determination is the accepted metric used. A higher iodine value denotes increased unsaturation, which implies greater susceptibility of the lipids to oxidative degradation, a property not suitable for biodiesel. Based on iodine value, oils are categorized into three classes: Drying oils with iodine value exceeding 125, Semidrying oils with iodine value ranging from 110 to 140 while the value below 110 is for non-drying oils (Ifijen and Nkwor, 2020). The iodine value of 39.99 $mgI_2/100$ g obtained for *Luffa cylindrica* seed raw oil in this investigation classifies it as a non-drying oil; it also indicates a significant divergence from the values (96.29 and 102.61 $mgI_2/100$ g) documented in literature by Ozulu (2016), and Aremu and Amos (2010). The value also was significantly lower than the 93.0 $mgI_2/100g$ obtained by Edward (2010) for *Jatropha curcas* oil. The iodine value (39.99 $mgI_2/100$ g) of *Luffa cylindrica* seed oil obtained in the present study underscored the long storage stability of the oil, as oils with low iodine values are less prone to oxidation (Okparanta *et al*., 2018). Notably, the iodine values of raw oil biodiesel (35 $mgI_2/100$ g) and degummed oil biodiesel (15 $mgI_2/100$ g) exhibited a progressive decrease, indicating improved oxidative stability. The iodine value obtained for both raw and de-gummed oil biodiesels were within the European standard which is 120 $mgI_2/100$ g. The significant reduction in iodine value following degumming suggests effective removal of unsaturated compounds, a situation that could enhance the stability of the oil (Sanni *et al*., 2018).

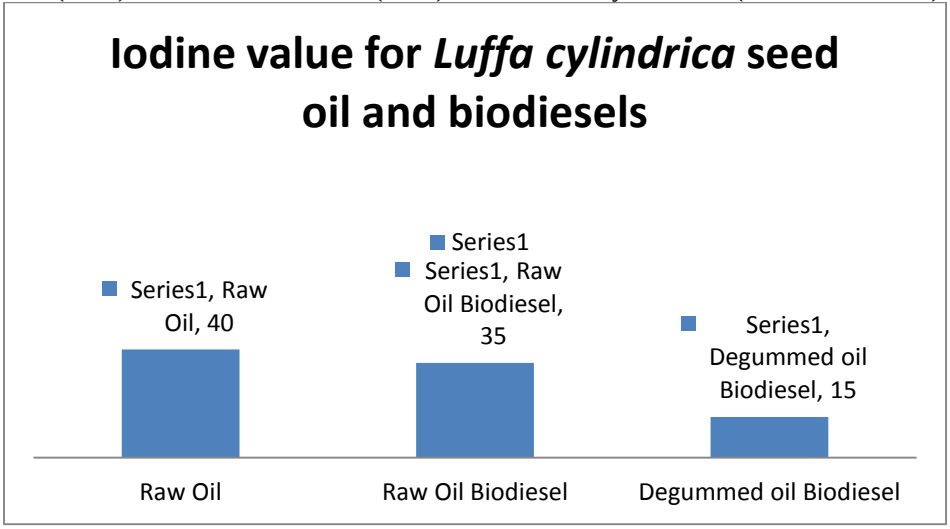


Figure 3: Iodine Value ($mgI_2/100$ g)

Peroxide value

This study found the peroxide value of *Luffa cylindrica* raw oil to be 30 meq/kg as shown in Figure 4. This value was higher than the value reported for *Jatropha* (1.93 meq/kg), shea-nut (0.28 meq/kg), and *Arachis hypogaea* (22.25 meq/kg) oils by Oyelaran *et al* 2022. The WHO/FAO stipulated maximum peroxide limit is 10 meq/kg. Biodiesel production and degumming notably reduced peroxide values to 10 meq/kg and 6 meq/kg, respectively. Elevated peroxide values are indication of oil instability and susceptibility to rancidity. However, processing enhances oil stability and shelf life by reducing lipolytic and oxidative activities, as observed in this study (Oyelaran *et al*., 2022).

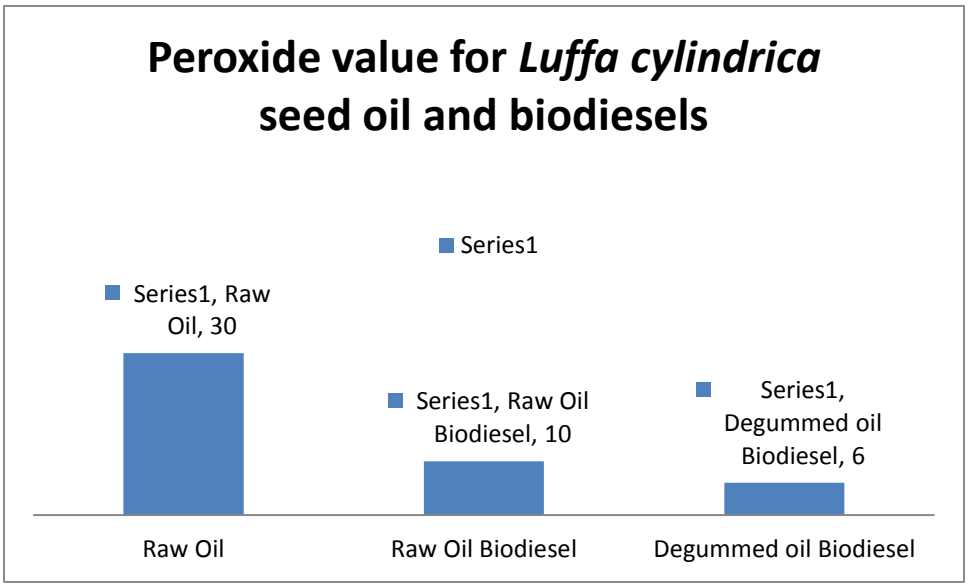


Figure 4 Peroxide value (meg/kg)

Free fatty acid

The presence of free fatty acids (FFA) in vegetable oils results from the hydrolytic cleavage of triglycerides (TG) (Menalla *et al*., 2024). In oils, FFA formation primarily arises from various factors, including oil production processes, storage conditions, and handling of raw materials (Ahmad *et al*., 2020; Edyson *et al*, 2022). Moreover, lipid deterioration processes, such as oxidation and enzymatic degradation, contribute to the generation of FFA, further impacting oil quality and stability. The value of free fatty acid obtained for *Luffa cylindrical* oil from this study was 16.28. This value was higher than 10.36 obtained for *Luffa cylindrica* oil by Abayeh (2013). The FFA of the raw oil biodiesel and that of the degummed oil biodiesel were 1.15 and 0.88 respectively. The reduction in the free fatty acids of the biodiesel might be due to sodium hydroxide (NaOH) catalyst used during transesterification process which, most likely, aided the conversion of free fatty acids to biodiesel.

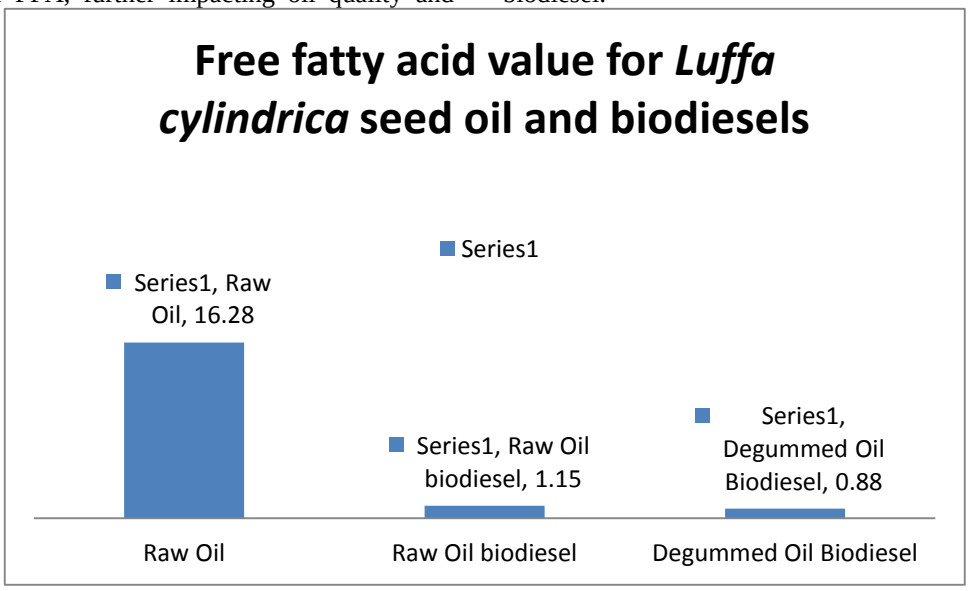


Figure 5: Free Fatty Acid.

Percentage biodiesel yield.

From Table 1, it can be seen that the percentage biodiesel yield from degummed oil of *Luffa cylindrica* was 95.00% while that of raw oil was found to be 79.04% under the same conditions of transesterification. The 16.80% difference in biodiesel yield might be ascribed to the degumming process of the oil which removed gummy materials such as waxes and phosphatides that

were capable of contributing immensely to poor conversion rate of oil to biodiesel. The presence of these gums could hinder the transesterification process by deactivating the catalyst, and impeding glycerol phase separation (Sharma *et al*., 2019). The result obtained in this study was consistent in pattern with that of Adekunle *et al*. (2016) and Sanni *et al*. (2018) in which both recorded high biodiesel yields after degumming oils.

Kinematic Viscosity

Kinematic viscosity of both raw oil and degummed oil biodiesels of *Luffa cylindrica* seed are shown in Table 1. The kinematic viscosity at 40°C values obtained for raw and degummed oil biodiesel were 15.3 mm^2/s and 3.80 mm^2/s respectively with percentage difference of 75.24%. These values indicated a significant reduction in viscosity after degumming. The improvement recorded suggested enhanced fuel flow and atomization which might lead to better engine performance and efficiency, as well as reduced engine wear and tear. Comparing these values to the established biodiesel standards, the degummed oil biodiesel met the ASTM D6751 (1.9 - 6.0 mm^2/s at 40°C) and EN 14214 (3.5 - 5.0 mm^2/s at 40°C), indicating suitable viscosity for diesel engines. In relation to other studies, the degummed oil biodiesel had a comparable or lower viscosity than the 4.5 - 5.5 mm^2/s recorded for *Jatropha curcas* biodiesel by Kumar *et al*. (2023), or 5.5-6.5 mm^2/s for palm oil biodiesel (Taher *et al.*, 2016). The substantial kinematic viscosity reduction after degumming observed in this study is consistent with the reports given by Mustapha *et al*. (2020) and Paola *et al.*(2020) on the reduction in the value of kinematic viscosity after degumming waste cooking oil and tilapia oil biodiesel. During degumming, impurities that enhance the viscosity of oil are usually removed (Lamas *et al*., 2016) which implies that degumming process effectively enhances fuel quality. Thus, without degumming, the raw oil biodiesel may require additional processing or blending to meet viscosity standards, whereas the degummed oil biodiesel is suitable for diesel engines, potentially improving performance and efficiency. High viscous oil biodiesel increases emission of CO_2 while low viscous oil biodiesel mitigate such emission (Garcia *et al*., 2025).

Flash point, smoke point, cloud points and pour points.

The flash points of raw and degummed biodiesels were recorded at 160 °C and 150 °C, respectively, while their smoke points measured 45 °C and 33 °C. Impact of degumming on these parameters strongly suggested phospholipid removal as a contributing factor. The initial presence of phospholipids likely elevated the raw biodiesel's flash point (Sani *et al*., 2018). The flash points of both biodiesels exceeded ASTM (130 °C) and European standard (120 °C) minimum flash point requirements, ensuring safe handling, transportation, and storage. The derived biodiesels cloud and pour points from raw and degummed *Luffa cylindrica* seed oil are also shown in the table. Notably, degumming significantly impacted these properties. The cloud point decreased from 19 °C (raw oil biodiesel) to 3°C (degummed oil biodiesel) having 84.21% percentage difference, while the pour point dropped from 3.9 °C to 2.1 °C having percentage difference of 46.15%. Similar trend was reported by Auwalu *et al*., (2025) about reduction in the values of flash point and pour point after treatment of biodiesel produced from Calabash oil. The absence of standardized limits for cloud and pour points in ASTM guidelines can be attributed to regional variations in climate conditions, necessitating adaptable biodiesel properties (Anwar and Rashid, 2008). This flexibility allows for tailored biodiesel formulations suited to specific geographic requirements. The observed reduction in cloud and pour points following degumming suggests a correlation with decreased oil unsaturation levels. This improvement probably enhanced the biodiesel's cold-flow properties, making it more suitable for diverse environmental conditions.

Cetane Number.

Cetane number is an indication of the time it takes for ignition to take place after diesel fuel has been injected into the combustion chamber. When the value of cetane is high, it implies that there will only be a short delay in ignition and fuel injection (Chen *et al*., 2025). Increased cetane number ensures good start and smooth running of engine (Sanni *et al*., 2018). The cetane number for both the raw and the degummed biodiesel were 43.97 and 68.76 respectively with percentage increase of 36.05%. The degummed biodiesel exhibited cetane numbers surpassing the minimum requirements of 47 for ASTM D6751 and 51 for EN 14214, while the raw biodiesel fell short of both standards. Studies indicates that increased saturation levels is capable of enhancing cetane numbers (Adekunle *et al*., 2016). The observed improvement in cetane number for degummed oil likely stems from reduced unsaturation. This trend aligns with findings from *Terminalia catappa* seed oil biodiesel, where degumming elevated cetane numbers from 49.78 to 52.84 (Sani *et al.*, 2018). This result also corroborates the observation of Adekunle *et al*. (2016) that degumming non-conventional seed oils yields higher cetane numbers.

Heating Value

Although ASTM D6751 and EN 14214 do not stipulate heating value requirements for biodiesel, European standards for biodiesel heating oil set a minimum threshold of 35 mg/kg (Sokoto *et al.*, 2011). This research revealed heating values of 43.97 mg/kg for raw oil biodiesel and 45.93 mg/kg for degummed oil biodiesel, implying that both values outshot the least requirement. Degumming positive impact on heating value indicated potential improvements in energy

efficiency. The reduction in the level of unsaturation during degumming might have led to increase in the observed heating value of the degummed biodiesel (Sokoto *et al*., 2011). Considering the heating value recorded for both raw and degummed oils indicated that they might be potential alternatives to petroleum diesel production.

Heating Efficiency

Heating efficiency, a critical parameter assessing heat transfer to a substance, indicates biodiesel's potential as a conventional fuel substitute (Rahman *et al*., 2025). In the present study, degumming significantly enhanced heating efficiency, increasing from 16,744 (raw oil biodiesel) to 19,757 (degummed oil biodiesel). This improvement underscored degummed biodiesel's superior energy transfer capabilities. Comparing biodiesels from raw and degummed oils to petroleum-based diesel, there was a notable difference in heating efficiency. Conventional diesel recorded 17,850 J/°C. In contrast, biodiesel from raw oil showed heating efficiency of 16,744 while degummed oil biodiesel showed 19,757 J/°C, respectively. However, the degummed oil biodiesel displayed improved heating efficiency, likely due to reduced unsaturation levels, as higher saturation degrees correlate with increased heating energy (Sokoto *et al*., 2011).

Table 1: Properties of Biodiesel from Raw and Degummed oil of *Luffa cylindrica*

Parameters	Raw Oil Biodiesel	Degummed Oil Biodiesel	% Difference
Kinematic viscosity	15.35 mm^2/s	3.80 mm^2/s	75.24
Flash point (°C)	160	150	6.25
Pour point (°C)	3.9	2.1	46.15
Cloud point (°C)	19	3	84.21
Smoke point (°C)	45	33	26.66
Cetane number	43.97	68.76	36.05
Heating value Mj/kg	43.78	45.93	4.68
Heating Efficiency J/°C	16,744	19,757	15.25
Biodiesel yield	79.04 %	95.00 %	16.80

CONCLUSION.

Degumming the oil obtained from the seeds of *Luffa cylindrica* improved the physicochemical and biodiesel properties of the oil. The biodiesel yield derived from degummed oil surpassed that of raw oil. The degummed oil biodiesel also exhibited superior fuel characteristics that better conformed to ASTM standards, compared to biodiesel produced from untreated *Luffa cylindrica* oil. The high yield and enhanced biodiesel properties of degummed oil from the seeds suggested its viability as a promising feedstock for biodiesel production.

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