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Evaluation of Physicochemical and Spectroscopic Properties of *Delonix regia, Jatropha curcas* and *Hura crepitans* Oil Extracts

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ABSTRACT

The escalating global demand for vegetable oils, propelled by their extensive utilization in both culinary and industrial sectors, necessitates the exploration of sustainable and locally available alternatives. This study evaluates the feasibility of oil extracts from under-utilized plant seeds native to the Niger Delta region, specifically Delonix regia, Jatropha curcas, and Hura crepitans. The oil content of the seeds was found to be 8.4%, 54.6%, and 66.4%, respectively. Key physicochemical properties, including density (0.86–0.89 g/cm³), viscosity (11.8–30.04 mPa•s), and saponification value (117.81–277.85 mg KOH/g), were assessed. The findings indicate that the oil properties of these seed extracts are largely comparable to those of Cocos nucifera oil, meeting several standards for biofuel production and oleochemical applications. This study highlights the potential of under-utilized Niger Delta plant oils as sustainable alternatives to conventional vegetable oils, contributing to the diversification of renewable resources for industrial and energy purposes.

Keywords: *Delonix regia, Jatropha curcas, Hura crepitans, Cocos nucifera Oil, Biofuels, Oleochemicals, Niger Delta, Physiochemical Properties, GCMS and FTIR.*

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INTRODUCTION

Due to the ongoing demand for edible and industrial oils, various sources of oil, particularly seeds from relatively neglected plants that are abundant in our area, are constantly being investigated to determine their feasibility as industrial feedstock, thereby supplementing the existing ones. *Delonix regia, Jatropha curcas, and Hura crepitans* are three examples of such plants. *Delonix regia* is a legume from the Caesalpiniaceae family (Onyedeji et al., 2017). It is a magnificent, semi-deciduous tree known as the Flame of the Forest in Nigeria, growing to a height of around 18 metres. It is easily propagated from seeds, but germinates slowly.

Leaflets are less than 12 mm long, with several flowers on long stalks. The leaflets are opposite, and the flowers are showy and scarlet. The fruits are long pods that hang from the branches and are green and flaccid when young, turning dark brown and rigid when ripe. Arora et al. (2010), Rani et al. (2011), and Bake et al. (2014) have reported that the mature fruit breaks open into two halves upon ripening, exposing the elongated hard seeds. Bioactive compounds and essential minerals, including tannin, saponin, phenolics, and flavonoids, as well as reducing sugars, triterpenoids, anthraquinones, amino acids, alkaloids, sodium, potassium, calcium, phosphorus, and

iron, were found in *Delonix regia*, according to pharmacological, phytochemical, and proximate analysis. Roy et al. (2013); Kumar et al. (2013)). The mature seeds are reportedly toxic due to their anti-nutrient contents (Amata et al., 2013). Fatty acids, acylglycerols and amino acids from mature seed oil extracts are being characterized for their usefulness in the industries and as animal feeds.

The Hura crepitans plant is an evergreen tree from the *Euphobiaceae fa*mily that is extensively grown in Nigerian cities and villages. Despite its abundance, the plant is underutilized, with the bulk of its seed oil insufficiently analyzed (Oderinde et al., 2009; Oyeleke et al., 2016). This is especially true for the Nigerian flora, which is one of the most diverse in continental Africa (Oderinde et al., 1990). They are among the largest trees of tropical America (Swaine & Beer, 1977) and are interesting for their pumpkin-shaped seed capsules that explode with a loud report, scattering the seeds.

Humans brought them to Africa as shade plants, but they have drawbacks, including poisonous leaves, bark, and seeds, as well as capsules that explode with enough force to hurt people or animals and spread seed up to 14 meters away (Swaine & Beer, 1977). They are occasionally grown as boulevard trees.

Fruits are capsules that range in size from 3 to 5 cm in length and 5 to 8 cm in diameter. The seeds are flattened to a diameter of roughly 15 to 25 mm, and 16 carpels are distributed wildly around the central axis. Its enormous seeds may germinate and develop in deep darkness, allowing the plant to penetrate undistributed forest. Trees are associated with lowland tropical to subtropical moist forest environment.

Hura crepitans are essentially not among the popularly cultivated of oilseeds like groundnut, soybean, palm fruit and palm seed in Nigeria. *The shrub plant family Euphorbiaccae includes Jatropha curcas* (Adebowale et al, 2006; Nayak & Patel, 2010). Although it originated in North America, the plant is currently grown and does well throughout Asia and Africa. Given its excellent yields and comparatively quick growth, it is simple to establish (Wills, 1967).

Because of its low moisture needs, low fertility requirements, and ability to withstand high temperatures, *Jatropha curcas* may thrive in harsh climates (Kaushik et al. 2007). During the dry season, this succulent tree loses its leaves. It is frequently used to reduce erosion and adapts well to dry and semi-arid environments (Nayak et al., 2010).

The branches are chewing sticks, and the leaves are used as antiseptics after birth or in traditional medicine to treat coughs (Gübitz et al., 1999). The branches' latex is beneficial for wound healing and other medical applications. Two to three black, rectangular seeds that can yield oil are found in each berry.

Forty to sixty percent (w/w) of the seed kernel oil was oil (Shukla et al., 1996; Makkar et al., 1997). According to Gübitz et al. (1999), the extracted seed oil has applications in medicine, veterinary care, pesticide, soap manufacturing, and fuel substitution. Between 78 and 84 percent of *jatropha curcas* oil is unsaturated fatty acid. Because of this, the oils could be used to produce biodiesel. However, the chemical contents of the oil change according to the temperature and geography.

The data reported by Nayak and Patel (2010) provide useful insights into the composition of Jatropha seeds, with an emphasis on their oil, protein, and ash content. According to their findings, Jatropha seeds contain 46.31% oil and 22.50% protein. These figures demonstrate Jatropha's potential as a biofuel source because of its high oil content, which is consistent with its increasing attention in studies on renewable energy. The substantial protein content of the seeds is said to be a contributing factor to their toxicity and unpleasant smell, which makes it difficult to use them for non-fuel applications like animal feed or other agricultural uses.

According to an analysis by Nayak and Patel (2010), the moisture content of *Jatropha curcas* was 5.80%, whereas the volatile matter content was 4.56%. These discoveries highlight possible industrial uses while illuminating its chemical and physical characteristics. With a saponification value of 194.70 mg/g for *Jatropha curcas* oil, Nayak and Patel (2010) demonstrated the oil's potential for industrial uses, especially in the manufacturing of soap.

Nayak and Patel (2010) investigated the fatty acid profile of *Jatropha curcas* seed oil, finding a blend of saturated (24.36%) and unsaturated (75.64%) fatty acids. This important parameter highlights the oil's suitability as a feedstock, promoting further investigation of its physicochemical characteristics and wider applications. Palmitic acid (16.69%) and stearic acid (7.67%) were the most common saturated fatty acids, whereas oleic acid (40.39%), linoleic acid (33.19%), and palmitoleic acid (0.96%) were the most common unsaturated fatty acids. These results highlight the oil's high unsaturated fatty acid content and prospective uses in industry and nutrition (Table 1).

Table1. Characterization of *Jatropha curcas* Seed

Analytical parameter	Values
Weight of 1000 seeds	540.51 g
Volume of 1000 seeds	730.00 mL
Oil content (% v/w)	46.31
Moisture and volatilities (% w/w)	05.80
Ash content (% w/w)	4.56
Colour	Dull brownish black
Odour	Disagreeable
Taste	Bitter
Protein % w/w (on dry basis)	22.50

Source: Nayak & Patel (2010).

Oyelade, et al. (2017) explored the potential of sandbox (*Hura crepitans*) oil for biodiesel production. Optimal conditions—1.5% catalyst concentration, 65°C reaction temperature, and 1 hour 47 minutes reaction time—yielded 93.79% biodiesel with a desirability value of 0.931,

highlighting its promise as a sustainable diesel alternative. Otoikhian et al. (2016) conducted an analysis of the biodiesel feedstock and discovered important physicochemical characteristics. With a flash point of 249°C and an acid value of 8.49 mg KOH/g, the substance showed excellent thermal stability. Its performance was demonstrated throughout a range of temperatures with cloud point and pour point of 11°C and -6°C, respectively. Biodiesel requirements were met by the observed density of 919.38 kg/m³ and the kinematic viscosity of 59.88 Cst. Water and residue levels came to 2.686%, but the sulfur content was low at 0.0174 percent. The brownish feedstock's iodine value of 164.34 g/100g and free fatty acid content of 4.15% indicated its degree of unsaturation. Its saponification value was 236.12 mg KOH/g, with free and total glycerin at 0.614 and 8.253%, respectively, and an oil yield of 38.40%. These characteristics indicate the feedstock's potential for biodiesel production, which is consistent with important performance criteria. The purpose of this study is to investigate the viability and industrial potential of oil extracts derived from underutilized Niger Delta plants. Concentrated on the seed oils of *Delonix regia, Jatropha curcas, and Hura crepitans*, resulting in 30-60% oil by volume. It investigates their structure, function, and long-term applications.

MATERIALS AND METHODS

Seed Samples

Between October and December 2023, mature pods of *Delonix regia* and *Jatropha curcas* were harvested from trees on the campus of Igbinedion University in Okada (6°43'49"N, 5°23'45"E), while *Hura crepitans* seeds were obtained from trees at the University of Port Harcourt in Choba (4.9071°N, 6.9170°E). The seeds were removed from the pods, cleaned with distilled deionized water, then oven dried at 60 degrees Celsius. The dried seeds were then mashed with a blender, sieved, and stored in an airtight container labeled Dr, Hc, and Jc for future study (Figures 1-3).

Figure 1: Jatropha curcas seeds

Figure 2: Delonix regia seeds

Figure 3: Hura crepitans seeds

Extraction of seed oil

The seed oils of *Delonix regia*, *Hura crepitans*, and *Jatropha curcas* were extracted using a Soxhlet apparatus with n-hexane as the de-waxing solvent. The extraction setup consisted of a reflux condenser, thimble, distillation flask, heating mantle, and retort stand.

For every type of seed, 300 g of the crushed sample was put in the thimble of the Soxhlet extractor, lined with Whatman filter paper, and then refluxed with n-hexane at 60 to 70 °C. The hexane was heated until it evaporated, then it went up the distillation arm and condensed into the thimble chamber that held the solid material. The vapors of the hexane were cooled by the condenser, which caused them to drip back into the thimble, where the warm solvent slowly dissolved the waxes and oils. O To make sure that no solid particles were transferred to the still pot, the siphon drained the chamber when it was almost full, returning the solvent to the distillation flask. Over the course of several hours, this procedure was carried out numerous times. Following extraction, the oil extract was placed in a bottle for subsequent processing and oven-dried for three hours at 60 °C. The seed samples of *Hura crepitans* and *Jatropha curcas* underwent the same process.

Characterization of raw oil extracts

Physicochemical analysis

The methods outlined by Akintayo (2004), Warra (2012), Hareesh et al. (2013), Akhabue et al. (2015), Sulaiman et al. (2016), Azuokwu et al. (2020), and others were used to examine the oil yield, acid value, density, free fatty acid (FFA), viscosity, saponification value, and surfactant production. Just to determine the special qualities of the local feedstock, the components of raw oil were examined. In addition to producing surfactants, this study shed light on their special qualities and potential industrial uses.

Oil yield

The respective oil yields were calculated using the Equation 1 below:

$$Oil\ yield\ (\%) = \left(\frac{W1 - W2}{W1}\right)\ X\ 100 \quad (1)$$

Where W_1 and W_2 are sample weight before and after oil extraction respectively.

Colour and odour

According to Azuokwu et al., (2024); Joseph et al., (2024); Mahulette et al., (2020), color charts were used to visually observe the oil samples' colors. A smell organ method described by Babatunde & Umoru (2016) was used to assess the odor. A glass-stoppered bottle was rinsed with distilled water after being internally cleaned with 3 M HCl. After adding half of the oil sample to the bottle, it was shaken violently for about two minutes. The nostrils were placed close to the bottle's aperture to monitor the odor once the stopper was removed.

Acid value and free fatty acid

Following the guidelines in AOCS Cd 3a-63, AOCS 5a-40, AOAC Official Method 940.28, ASTM D5555-95, and ASTM D664 (Rafiu et al., 2022; Rubalya et al., 2016; Dimberu & Belete, 2011; Michael, 2015), the titrimetric method was used to determine the acid values and free fatty acid compositions of the oils. A 0.05M KOH solution was made by dissolving 2.805g KOH (pellet) in 1000ml of distilled water. In addition, a 1:1 volume ratio of 99.7% pure ethanol and 98% pure benzene was created by combining 50 ml of benzene and 50 ml of ethanol. About 1g of the oil sample was weighed and dissolved in the mixture of ethanol and benzene. The solution was titrated with 0.1N KOH solution in the presence of 2 drops of phenolphthalein as an indicator until the end point was reached with the appearance of a pale permanent pink. The acid value in mgKOH/g and free fatty acid (%) were calculated.

$$\text{Acid value, } AV = \frac{MW \times N \times V}{W} \quad (2)$$

$$\%\ \text{Free Fatty Acid, FFA} = \frac{\text{AV}}{2} \quad (3)$$

Where:
AV (mgKOH/g) = Acid value in mgKOH/g, MW = Molecular weight of potassium hydroxide (56.1g), N = Normality of potassium hydroxide solution (0.1 N), V = Volume of potassium hydroxide solution used in titration, W = Weight of oil sample.

Saponification Value

The saponification value (SV) reflects the average molecular mass of fatty acids in an oil sample. It was determined using the titrimetric method in accordance with ASTM D5558–95, AOCS Cd 3-25, and AOAC 920.160 standard procedures (Rafiu et al., 2022; Rubalya et al., 2016; Dimberu & Belete, 2011; Michael, 2015). One gram (1.0 g) of the oil sample was weighed into a 250 mL glass conical flask, followed by the addition of 10 mL of an ethanol and benzene mixture (1:1) and 25 mL of 0.5 N ethanolic potassium hydroxide. After installing a reflux condenser, the flask was heated for 30 minutes in a boiling water bath while being shaken occasionally. Once the solution was heated, two to three drops of phenolphthalein indicator were added. The solution was then titrated against 0.5 M HCl until the pink tint vanished. Other samples and a blank were subjected to the same process. The formula shown in Equation 4 was used to determine the saponification value (SV).

$$S.V = \frac{(b - s) \times 56.1 \times n}{w} \quad (4)$$

Where
b = the volume of the solution for blank test; s = the volume of sample solution for determination;
n = Actual normality of the HCl (0.1M); w = Mass of the sample; 56.1 = Molar mass of KOH in g

Viscosity

Viscosity value provides insight on the rheological behaviour of oil samples. Brookfield NDJ-5S Rotary viscometer was utilized in the determination of viscosity. The proper spindle number was chosen for the test sample and gently installed on the machine. A 250ml beaker was cleaned, and the sample was poured up to 200ml capacity. The beaker was then placed on a water bath with temperature pre-set at constant 30°C and allowed to equilibrate for 10 minutes. The spindle and the temperature sensor of the machine were then lowered into the sample and the power button was turned on. The appropriate spindle number and speed were selected on the display screen and followed by the run button. The machine was then allowed to read the viscosity until a stable value was obtained and recorded.

Specific gravity

Density bottle was used in determining the specific gravity of the oil extracts. A clean and dry stoppered bottle of 25 ml capacity was weighed (W_0) and then filled with the oil stoppered and reweighed to give (W_1). The oil was substituted with distilled water after washing and drying the bottle and weighed to give (W_2). The expression for specific gravity (Sp.gr) was:

$$Sp.gr = \frac{W_1 - W_2}{W_2 - W_0} \quad (5)$$

Where
W_0 = weight of dry empty density bottle; W_1 = weight of density bottle + oil;
W_2 = weight of density bottle + distilled water.

Density

Density varies with temperature, increasing temperature leads to oil expansion thus decreasing oil density. 25 ml of sample was filled to mark in the pre-weighted density bottle and the temperature of sample was determined using a thermometer. The bottle (containing the sample) was weighed to determine the sample weight. The density was calculated using the mass-volume relationship as shown in Equation 6

$$Density = \frac{Mass\ of\ sample}{Volume\ of\ sample} \quad (6)$$

Spectroscopy analysis

The Fourier Transform Infra-red (FTIR) and Gas Chromatography-Mass Spectroscopy (GC-MS) analyses were used to identify and characterize the compositions and functional groups of the compounds present in the oil extracts (DRO, JCO and HCO) and synthesized fatty acid methyl ester sulphonates (DR_MES, JC_MES and HC_MES). These data were obtained by collecting high resolution spectral data over a wide spectral range in order to confirm the stability of the synthesis process. It is the standard for organic compound identification work in academic, analytical, quality control and, or quality assurance (QC/QA) and forensic laboratories (Innovatech Labs, 2022; Wikipedia, 2023).

Fatty acid analysis

The fatty acid composition of each sample oil was analyzed by injecting 1 mL of respective sample extracts into gas chromatography system (Agilent network GC system, model 7890A) coupled with Agilent Technologies Network Mass Selective Detector with 5975C Series Injector. The carrier gas was helium (99.99% purity) and the injector temperature was 250 °C with split-less modes. The column temperature was initially at 80 °C held for 1 min and increased at the rate of 10 °C/min to 200 °C held for 2 min and held at the rate of 20 °C/min to 300 °C for 8 min. The spectra of the separated compounds were compared with the database of the spectra of known compounds saved in the NIST02 Reference Spectra Library. Data analysis and peak area measurement were carried out with known experts.

FTIR analysis

Fourier transform Infra-red spectroscopy (Model: Agilent 3600; Range: 12000-100 cm^{-1}) was obtained for respective oil and surfactant extracts. Sample (1 to 2ml) was placed on a glass plate and observed at the different coming wavelengths in FTIR instrument. FTIR was used for the analysis of functional groups of residual components. The FTIR instrument sent infrared radiation of about 10,000 to100 cm^{-1} through the sample, with some radiation absorbed and some passed through. The absorbed radiation was converted into rotational and/or vibrational energy by the sample molecules. The resulting signal at the detector presents as a spectrum, typically from 4000 cm^{-1} to 400cm^{-1}, representing a molecular fingerprint of the sample (Fing *et al.,* 2012). Each molecule or chemical structure thus produces a unique spectral fingerprint (Wang and Weller, 2006).

RESULTS AND DISCUSSION

Physicochemical analysis

The physicochemical properties of seed oils from *Delonix regia, Jatropha curcas, and Hura crepitans* were analyzed and compared in this study. The results obtained were critically evaluated alongside findings from previous studies to highlight similarities, deviations, and potential implications for industrial applications (Table 2).

Colour

The observations on the color of oils extracted from *Delonix regia, Jatropha curcas, and Hura crepitans* seeds shed light on the stability of the extraction process and the little impact of environmental conditions on this parameter. The findings are consistent with earlier investigations, demonstrating the dependability and reproducibility of the approaches used.

The light brown tint of *Delonix regia* seed oil observed in this investigation supports Adewale et al.'s (2010) findings. This stability shows that the physical properties of *Delonix regia* oil are consistent throughout experiments and maybe across diverse environmental circumstances. Color consistency may imply a largely inert composition of pigments or other color-causing elements that are unaffected by modest differences in extraction procedures or seed sources.

Likewise, the amber hue of the *Jatropha curcas* oil found in this investigation is consistent with previous findings by Adebowale (2006). This uniformity across investigations indicates that the physical qualities of *Jatropha curcas* oil are resilient and that the product of its extraction has stable and predictable attributes. Certain carotenoids or phenolic chemicals in the oil may be responsible for the amber color since they seem to be resistant to processing-related environmental influences.

Hura crepitans oil also exhibited an amber color, consistent with the findings of Otoikhian et al. (2016). This alignment further supports the notion that the extraction process for *Hura crepitans* oil is stable and yields a product

Table 2: Comparative analysis of physicochemical properties of sample seed oils

PHYSIO-CHEMICAL PROPERTY	*Delonix regia* Seed oil			*Jatropha curcas* Seed oil			*Hura crepitans* Seed oil		
	Adewale et al (2010)	***Adejumo et al (2019)***	**This study**	**Adebowale (2006)**	**Azuokwu et al (2020)**	**This study**	**Otoikhian et al (2016)**	**Onuh et al (2019)**	**This study**
Colour	Light brown	NA	Light brown	Amber	NA	Amber	Brownish	NA	Amber
Oil yield (%)	7.0	29.0	8.4	66.4	61.0	54.6	38.4	37.0	66.4
Acid value (mg KOH/g)	NA	1.97	22.22	4.24	2.84	23.24	8.46	NA	48.59
Free Fatty Acid (%)	10.4	0.985	11.11	4.54	12.4	11.66	4.15	NA	24.30
Saponification value (mg KOH/g fat)	195.4	213.48	117.81	169.9	186.00	277.85	236.12	NA	174.99
Viscosity (mPa.s or cp)	NA	48.50	11.8	NA	48.2	30.04	59.88	14.7	11.9
Density ($g/cm^{3)}$	0.95	0.94	0.86	0.86	0.92	0.89	0.92	0.91	0.88

with reproducible physical attributes. The similarity between this study and prior literature suggests that the pigmentation compounds in *Hura crepitans* oil are not significantly influenced by environmental or procedural variations. The consistency in color across these three oils, as well as their agreement with previous studies, underscores the importance of standardized extraction techniques. It also suggests that these oils possess inherent stability in their physical characteristics, making them reliable for industrial or commercial applications where color uniformity may be a critical parameter.

Oil yield

When evaluating the economic viability of seed oils for industrial use, the oil production is a crucial consideration. At 8.4%, the oil production for *Delonix regia* in this study was noticeably lower than the 7.0% reported by Adewale et al. (2010). This suggests that *Delonix regia* might not be the best option for producing oil with a high yield. The high oil yield of 54.6% for *Jatropha curcas*, on the other hand, was somewhat less than the 66.4% and 61.0% reported by Adebowale (2006) and Azuokwu et al. (2020), respectively.

In this study, the yield for *Hura crepitans* was 66.4%, which is significantly higher than the 38.4% and 37.0% reported by Otoikhian et al. (2016) and Onuh et al. (2019), respectively, indicating improved extraction efficiency or superior seed quality. This variation could be attributed to differences in seed quality, extraction methods, or geographical origin.

Acid value (mg KOH/g)

This study found that the acid value of *Delonix regia* was 22.22 mg KOH/g, which was significantly higher than the 1.97 mg KOH/g reported by Adejumo et al. (2019). Similarly, *Jatropha curcas* had a significantly higher acid value of 23.24 mg KOH/g than Adebowale (2006) and Azuokwu et al. (2020), which were 4.24 mg KOH/g and 2.84 mg KOH/g, respectively. This shows that the oil may have degraded or that there are variances in post-harvest handling and storage circumstances. In this investigation, the acid value for *Hura crepitans* was 48.59 mg KOH/g, which was significantly higher than earlier results published by Otoikhian et al. (2016) of 8.46 mg KOH/g, indicating probable hydrolysis or oxidative degradation.

Free fatty acid (%)

Since the two parameters are closely related, the free fatty acid (FFA) content and the acid value follow a similar trend. The FFA content for *Delonix regia* was 11.11% in this study, higher than the 0.985% reported by Adejumo et al. (2019), while the FFA content for *Jatropha curcas* was 11.66%, comparable to the 12.4% reported by Azuokwu et al. (2020) but significantly higher than the 4.54% observed by Adebowale (2006). *Hura crepitans* had an exceptionally high FFA content of 24.30%, indicating poor quality or advanced degradation, compared to earlier findings by Otoikhian et al. (2016) at 4.15%. These elevated FFA levels may limit the oils' suitability for edible applications, but they could still be viable for biodiesel production after refining.

Saponification value (mg KOH/g fat)

The average molecular weight of the fatty acids in the oil and its capacity to produce soap are indicated by the saponification value. The value of 117.81 mg KOH/g for *Delonix regia* reported in this study was much lower than the 195.4 mg KOH/g found by Adewale et al. (2010) and the 213.48 mg KOH/g found by Adejumo et al. (2019), indicating a lower proportion of shorter-chain fatty acids in the current sample.

In contrast to earlier studies of 169.9 mg KOH/g by Adebowale (2006) and 186 mg KOH/g by Azuokwu et al. (2020), this study revealed a saponification value of 277.85 mg KOH/g in *Jatropha curcas*. This suggests that the fatty acid makeup of various research or seed sources may differ. Compared to the 236.12 mg KOH/g reported by Otoikhian et al. (2016), a value of 174.99 mg KOH/g was found for **Hura crepitans*, indicating heterogeneity in the fatty acid profile.

Viscosity (mPa.s or cp)

When evaluating flow characteristics and appropriateness for the manufacture of biodiesel, viscosity is a crucial criterion. This study found a viscosity of 11.8 mPa.s for *Delonix regia*, which is far lower than the 48.50 mPa.s found by Adejumo et al. (2019).

Likewise, viscosity dropped to 30.04 mPa.s for *Jatropha curcas* from 48.2 mPa.s for Azuokwu et al. (2020), suggesting possible variations in oil composition or processing conditions. Viscosity for **Hura crepitans** was comparatively low at 11.9 mPa.s., which is in line with the results of this investigation but significantly different from the 59.88 mPa.s. reported by Otoikhian et al. (2016).

Density (g/cm³)

When assessing the quality of oil and its viability for a range of uses, including the creation of biodiesel, density is a crucial characteristic. This study found that the density of *Delonix regia** oil was 0.86 g/cm³, which is less than the 0.95 g/cm³ found by Adewale et al. (2010) and the 0.94 g/cm³ found by Adejumo et al. (2019). This study's density of 0.89 g/cm³ for *Jatropha curcas** was in line with Adebowale's (2006) findings of 0.86 g/cm³ but marginally lower than earlier reports of 0.92 g/cm³ by Azuokwu et al. (2020). *Hura crepitans** also displayed a density of 0.88 g/cm³, which was in line with the findings of Otoikhian et al. (2016) but marginally lower than the 0.91 g/cm³ reported by Onuh et al. (2019).

Spectroscopy analysis of oil and green surfactant extracts

This section discusses the observations made from the spectroscopy analyses (GC-MS and FTIR). These analyses are the standard for organic compound identification work in academic, analytical, quality control and, or quality assurance (QC/QA) and forensic laboratories (Innovatech Labs, 2022; Wikipedia, 2023).

GCMS Results

The GCMS analytical results for the oils of Delonox regia, *Jatropha curcas*, and *Hura crepitans* are displayed in Figures 4, 5, 6 and Tables 3, 4, 5 below. The different profiles of prominent compounds found in the GCMS analysis of the oils extracted from *Hura crepitans*, *Jatropha curcas*, and *Delonix regia* indicate the diverse chemical compositions that are specific to each plant species. In order to contextualize and validate the results, a detailed discussion of the findings is provided below, along with comparisons to previous research.

***Delonix regia* Oil**

The main constituents of *Delonix regia* oil were determined by GCMS analysis to be benzene derivatives (1-ethyl-2-methyl, 1-ethyl-3-methyl, and 1-ethyl-4-methyl), dodecane, cyclododecane, and linoelaidic acid. These substances imply the presence of substantial aromatic hydrocarbons and long-chain alkanes in the oil, which may be suggestive of possible uses in industrial lubricants and biofuels. One notable application for linoelaidic acid, a trans-isomer of linoleic acid, is the creation of bio-based coatings and polymers. *Delonix regia* oil's presence of aromatic hydrocarbons is consistent with research on plant oils that include benzene derivatives, which have been linked to antibacterial and antioxidant qualities (Adebayo et al., 2018). However, since cyclododecane is less frequently recorded in plant oils and is frequently linked to specialized commercial uses as temporary consolidants in art restoration, this finding is especially intriguing (Smith et al., 2015). Its relevance and concentration in this setting require further research.

***Jatropha curcas* oil**

In the case of *Jatropha curcas*, the GCMS analysis revealed Oleic acid, Phenol, Carmabic acid, Methyl stearate, and Octadecenoic acid as the dominant compounds. Oleic acid, a monounsaturated fatty acid, is well-established in the literature as a key component of *Jatropha oil*, contributing to its high potential as a biodiesel feedstock (Azam et al., 2005). The presence of Methyl stearate further supports this application, as methyl esters are commonly derived during trans-esterification processes for biodiesel production. Both Carmabic acid and Phenol are notable for their bioactive qualities; Carmabic acid, though less commonly reported in plant oil studies, may merit additional research for its possible biological or industrial significance. Phenol has well-established antioxidant and antimicrobial activities (Shahidi & Zhong, 2010), which could extend the utility of *Jatropha curcas* oil beyond energy production to pharmaceutical and cosmetic applications.

***Hura crepitans* oil**

GCMS analysis of *Hura crepitans* identified Linoelaidic acid, Carbonic acid, Mestiylene, and Hexadecanoic acid as its main components. Linoelaidic acid, a dominant unsaturated fatty acid, mirrors *Delonix regia* in its profile. Hexadecanoic acid (palmitic acid), renowned for its emollient properties, finds extensive use in food, soap, and cosmetics (Gunstone et al., 2007). Mestiylene (1,3,5-trimethylbenzene) has potential in chemical synthesis and fuel additives. Meanwhile, the presence of carbonic acid, likely a byproduct of oil extraction or analysis, warrants further investigation to understand its role in the oil's chemical composition.

Comparison across oils

A comparative analysis of the three oils reveals both commonalities and unique features. Linoelaidic acid is a shared component between *Delonix regia* and *Hura crepitans*, suggesting a potential overlap in their fatty acid profiles. However, the presence of aromatic hydrocarbons such as Mestiylene in *Hura crepitans** and Benzene derivatives in *Delonix regia* highlights distinct chemical signatures that may influence their specific applications.
The predominance of Oleic acid in *Jatropha curcas*

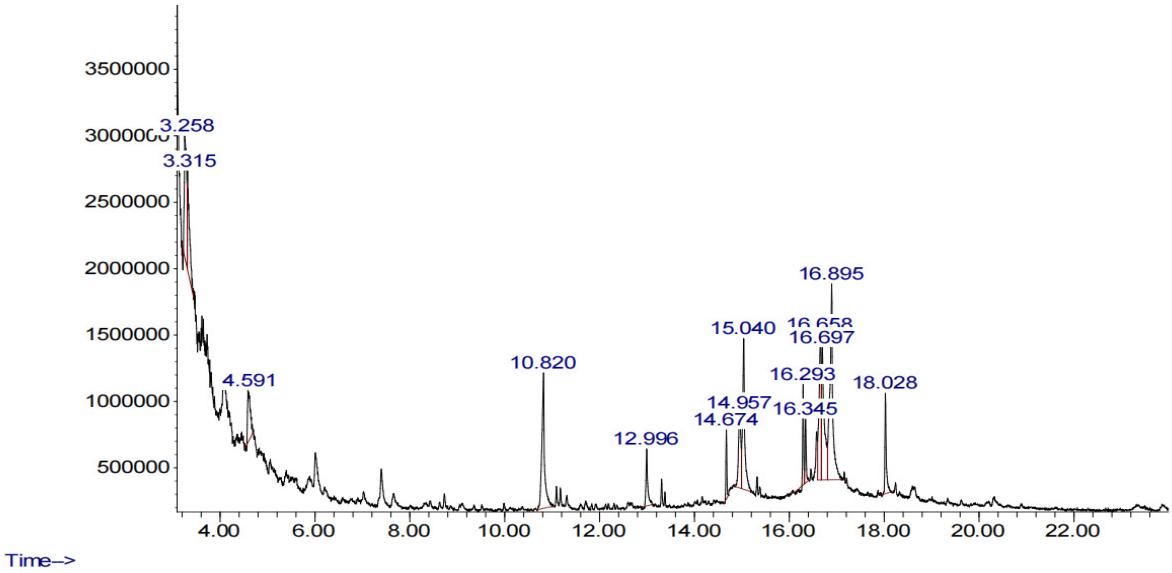

Figure 4: GC-MS Spectra of *Delonix regia* oil (DRO)

Table 3: Compound Revealed from *Delonix Regia* Oil Using GC-MS.

Peak Number	Retention Time	Area %	Name of Compound
1.	3.258	8.64	Benzene, 1-ethyl-2-methyl Benzene, 1-ethyl-4-methyl-
2.	3.315	6.65	Benzene, 1-ethyl-2-methyl Benzene, 1-ethyl-3-methyl- Benzene, 1-ethyl-4-methyl
3.	4.591	4.24	1-Octanol, 2-butyl Dodecane, 1-fluoro- Oxalic acid, monoamide, n-propyl, dodecyl ester
4.	10.818	11.25	Dodecanoic acid
5.	12.997	2.86	Cyclododecane 1-Dodecene 5-Tetradecene, (E)-
6.	14.673	2.01	Hexadecanoic acid, methyl ester
7.	14.958	5.60	Cyclododecane Acetic acid, chloro-, hexadecyl ester 1-Tridecene
8.	15.041	10.31	Cyclododecane Pentafluoropropionic acid, dodecyl ester Acetic acid, chloro-, hexadecyl ester
9.	16.292	2.58	10,13-Octadecadienoic acid, methy ester 9,12-Octadecadienoic acid (Z,Z)-, methyl ester 9,12-Octadecadienoic acid (Z,Z)-, methyl ester
10.	16.344	2.34	Trans-13-Octadecenoic acid, methy ester 11-Octadecenoic acid, methyl ester 9,17-Octadecadienal, (Z)-
11.	16.655	9.40	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid 9,12-Octadecadienoic acid (Z,Z)-
12.	16.697	11.64	Cyclopentadecanone, 2-hydroxy- 8-Heptadecene E,Z-1,3,12-Nonadecatriene
13.	16.894	18.23	2-Bromopropionic acid, pentadecyl ester n-Tetracosanol-1 Heptadecyl heptafluorobutyrate
14.	18.030	4.25	2(1H)-Benzocyclooctenone, decahydro-4a-methyl-, trans-(-) 9-Tetradecenal, (Z)- Z-12-Tetradecenal

reinforces its established role as a biodiesel candidate, while the diverse bioactive compounds detected across all three oils suggest broader applications in pharmaceuticals, cosmetics, and industrial formulations. These findings align with existing literature on plant-based oils but also highlight unique chemical markers that warrant further exploration.

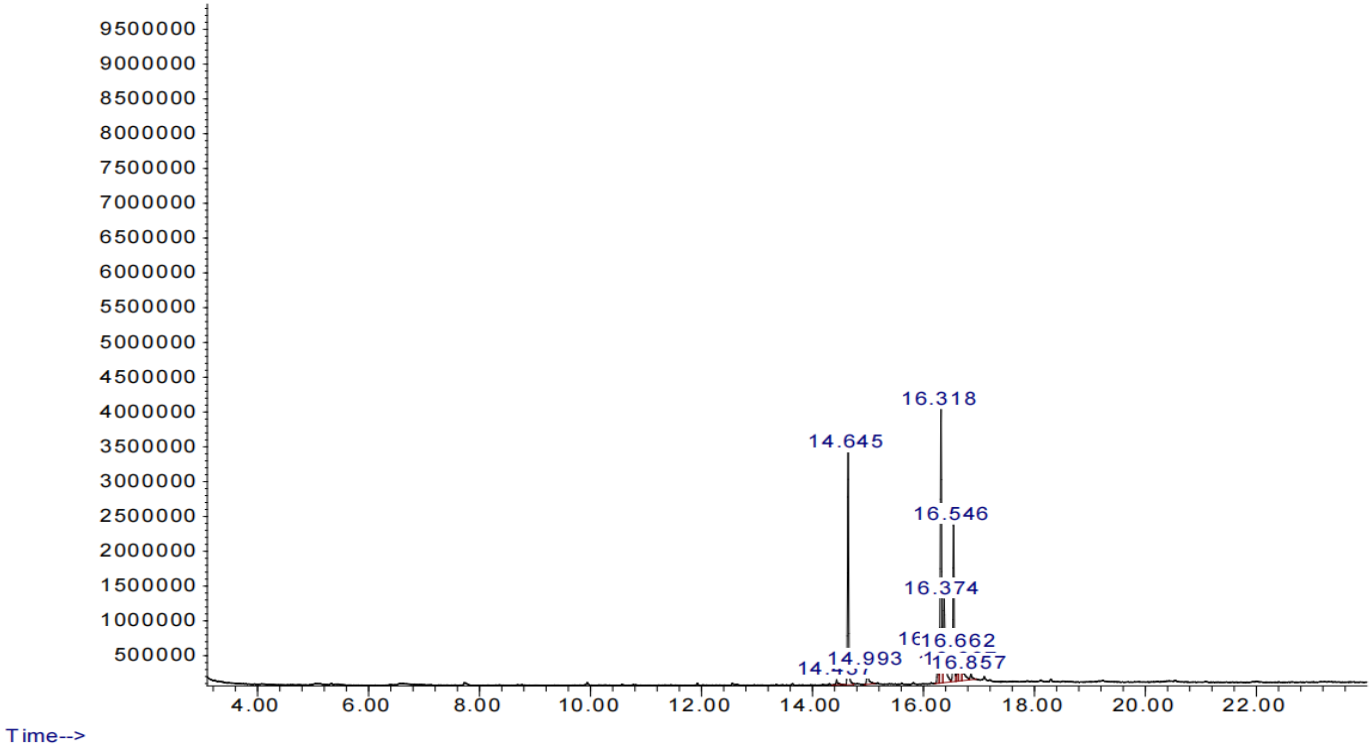

Figure 5: GC-MS Spectra of *Jatropha curcas* oil (JCO)

Table 5: Compound Revealed from *Jatropha curcas* oil using GC-MS.

Peak Number	Retention Time	Area %	Name of Compound
1.	14.440	0.76	Phosphonic acid, diphenyl ester Carbamic acid, phenyl ester Phenol
2.	14.647	22.96	Pentadecanoic acid, 14-methyl-, methyl ester Hexadecanoic acid, methyl ester Pentadecanoic acid, 14-methyl-, methyl ester
3.	14.995	2.57	n-Decanoic acid n-Hexadecanoic acid
4.	16.261	3.73	9,12-Octadecadienoic acid (Z,Z)-,methyl ester
5.	16.318	29.71	7-Octadecenoic acid, methyl ester 9-Octadecenoic acid (Z)-, methyl ester 12-Octadecenoic acid, methyl ester
6.	16.375	14.50	9-Octadecenoic acid (Z)-, methyl ester 12-Octadecenoic acid, methyl ester 6-Octadecenoic acid, methyl ester,(Z)-
7.	16.546	16.09	Methyl stearate
8.	16.614	1.45	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid
9.	16.660	4.28	cis-9-Hexadecenal 9-Octadecenoic acid cis-13-Octadecenoic acid
10.	16.697	2.95	Z-10-Pentadecen-1-ol Bicyclopentylidene Methyl 5,12-octadecadienoate
11.			Oleic Acid 4,7-Methano-1H-inden-1-ol, octahydro- 9-octadecanoic acid,-heptafluorobutyl ester

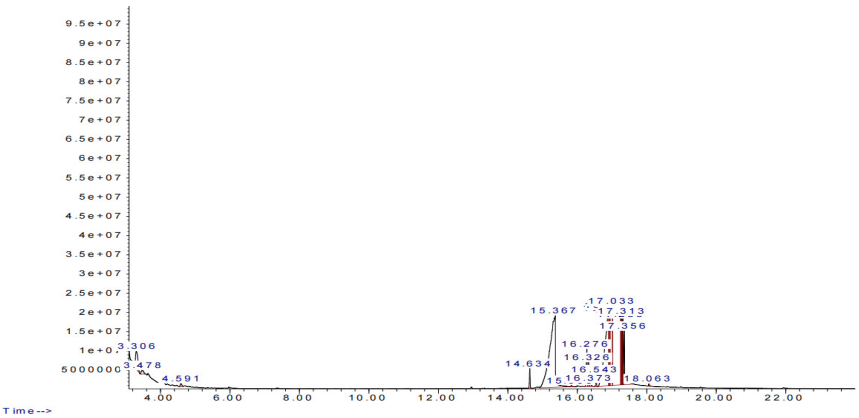

Figure 6: GC-MS Spectra of *Hura crepitans* oil (HCO)

Table 6: Compound Revealed from *Hura crepitans* oil using GC-MS.

Peak Number	Retention Time	Area %	Name of Compound
1.	3.305	2.33	Benzene, 1,2,4-trimethyl- Mesitylene Benzene, 1,2,4-trimethyl-
2.	3.476	0.46	Mesitylene Benzene, 1,2,4-trimethyl-
3.	4.591	0.24	Carbonic acid, prop-1-en-2-yl tridecyl ester Carbonic acid, decyl prop-1-en-2-yl ester Carbonic acid, nonyl prop-1-en-2-yl ester
4.	14.637	0.73	Pentadecanoic acid, 14-methyl-, methyl ester Hexadecanoic acid, methyl ester
5.	15.368	23.76	n-Hexadecanoic acid Tetradecanoic acid
6.	15.835	0.07	9-Octadecenal, (Z)- 9-Nonadecene 13-Tetradecenal
7.	16.276	1.73	9,12-Octadecadienoic acid, methyl ester 9,12-Octadecadienoic acid (Z,Z)-, methyl ester 9,12-Octadecadienoic acid, methyl ester, (E,E)
8.	16.328	0.95	9-Octadecenoic acid (Z)-, methyl ester 12-Octadecenoic acid, methyl ester 7-Octadecenoic acid, methyl ester
9.	16.375	0.20	9-Octadecenoic acid (Z)-, methyl ester 9-Octadecenoic acid (Z)-, 2,3-dihydroxy propyl ester trans-13-Octadecenoic acid, methyl ester
10	16.541	0.44	Heptadecanoic acid, 16-methyl-, methyl ester Methyl stearate 1
11.	16.889	15.34	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid
12.	16.935	4.81	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid
13.	16.997	9.22	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid
14.	17.034	28.56	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid
15.	17.252	3.00	9,12-Octadecadienoic acid (Z,Z)- Linoelaidic acid
16.	17.283	2.31	9,12-Octadecadienoic acid (Z,Z)- 9,17-Octadecadienal, (Z)- Linoelaidic acid
17.	17.314	2.82	cis-Vaccenic acid cis-13-Octadecenoic acid 9-Octadecenoic acid, (E)-
18.	17.355	2.93	Octadecanoic acid
19.	18.061	0.09	Tricosane Octadecane Nonadecane

Table 7: Fourier Transform Infrared Spectroscopy of *Delonix regia* oil (DRO)

(cm-1)	Intensity	Functional Group
417.46184	54.94673	Alkyl halides.
469.64457	73.89260	Alkyl halides
529.28197	78.40366	C-Br: (690-515) : Strong, Stretching, Halo
596.37405	92.12638	C-Br: (690-515):Strong, Stretching, Halo
723.10354	78.96402	C=C (730-665), Strong, Bending, Alkene
760.37692	90.34139	C-Cl (850-550) Strong, Stretching, Halo comp.
1103.29200	80.89351	C-O (1150-1085) Strong, Stretching, Aliphatic Ether
1162.92941	70.84076	C-O (1150-1085) Strong, Stretching, Aliphatic Ether
1371.66032	87.36645	S=O (1372-1335) Strong, Stretching, Sulfonate
1461.11643	78.98236	C-H (1465) Medium, Bending, Alkane
1744.39411	59.70111	C=O (1745) Strong, Stretching, cyclopentanone
2855.14078	68.56238	O-H (3300-2500), Strong, Stretching, Carboxylic acid
2922.23286	55.72319	C-O (3000-2840) Medium, Stretching, Alkane
3004.23430	93.74392	O-H (3300-2500), Strong, Stretching, Carboxylic acid

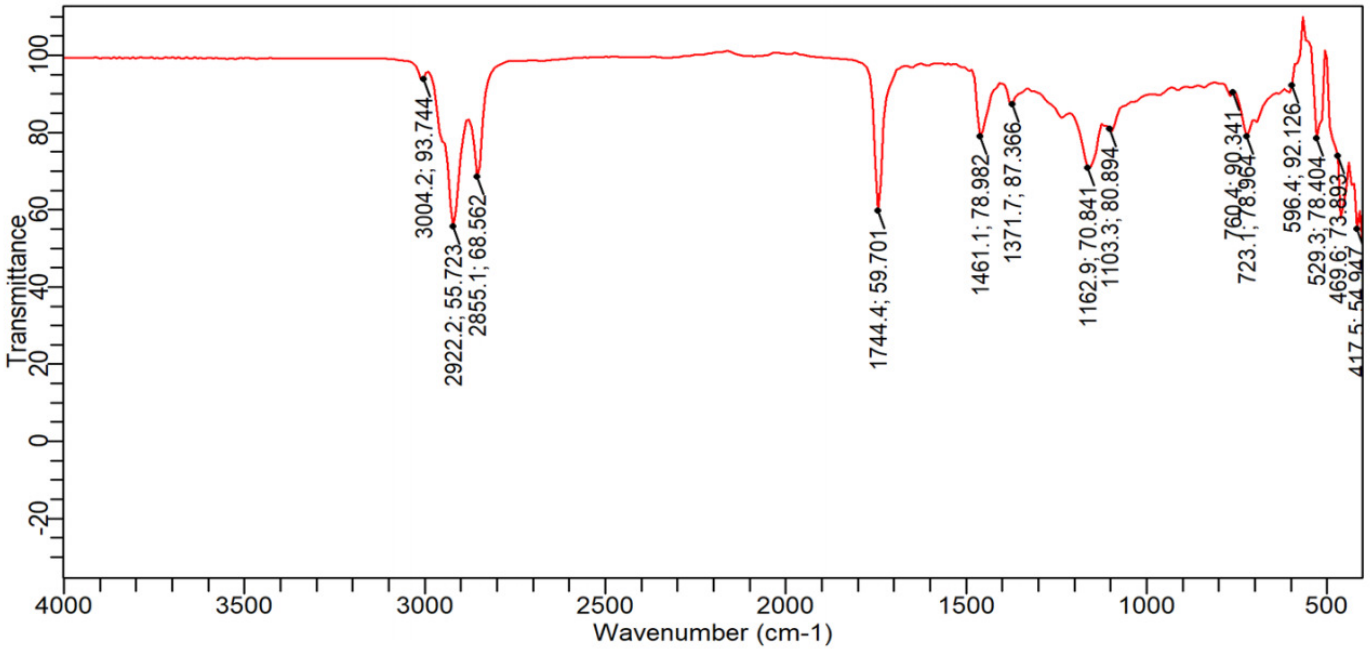

Figure 7: FTIR Spectra for *Delonix regia* Oil (DRO)

Table 8: Fourier Transform Infrared Spectroscopy of *Jatropha curcas* oil (JCO).

(cm-1)	Intensity	Functional Group
723.10354	78.65906	C=C, (730-665), Strong, Bending, Alkene
913.19777	93.88475	C=C, (915-905), Strong, Bending, Alkene
965.38050	92.58613	C=C, (980-960), Strong, Bending, Alkene
1159.20207	66.73792	C-O, (1205-1124), Strong, Stretching, Tertiary alcohol
1237.47616	83.01869	C-N, (1250-1020), Medium, Stretching, Amine
1375.38766	88.39482	S=O, (1370-1335), Strong, Stretching, Sulfonamide
1461.11643	80.41056	C-H, (1465), Medium, Bending, Alkane
1651.21066	97.74413	C=C, (1650-1566), Medium, Stretching, Cyclic Alkene
1744.39411	56.09818	C=O, (1750-1735), Strong, Stretching, Esters
2851.41345	64.05865	N-H, (3000-2800), Strong, Stretching, Amine salt.
2922.23286	53.35693	C-H, (3000-2840), Medium, Stretching, Alkane
3004.23430	94.69860	C-H, (3100-3000), Medium, Stretching, Alkene

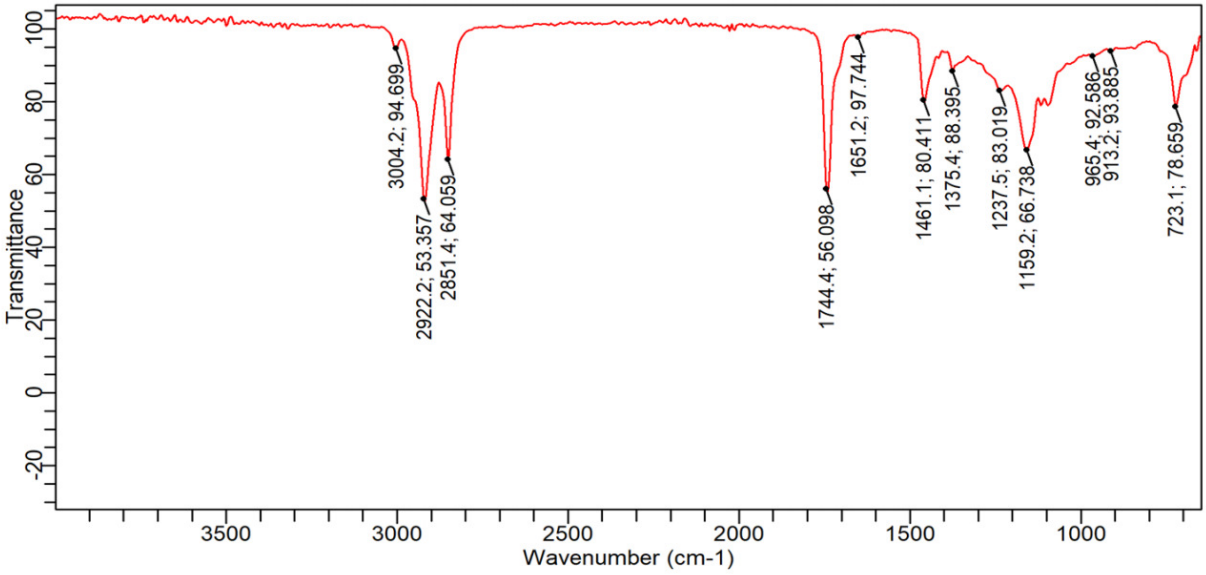

Figure 8: FTIR Spectra for *Jatropha curcas* Oil (JCO)

Table 9: Fourier Transform Infrared Spectroscopy of *Hura crepitans* oil (JCO).

(cm-1)	Intensity	Functional Group
726.83088	76.94441	C=C, (730-665), Strong, Bending, Alkene
767.83159	93.03155	C-H, (750 ± 20), Strong, Bending, Benzene derivative
913.19777	93.03854	C=C, (915-905), Strong, Bending, Alkene
946.74381	93.09149	C=C, (980-950), Strong, Bending, Alkene
1095.83732	85.65727	C-O, (1124-1087), Strong, Stretching, Sec. alcohol.
1159.20207	76.45625	S=O, (1160-1120), Strong, Stretching, Sulfone
1237.47616	86.52720	C-N, (1250-1020), Medium, Stretching, Amine
1375.38766	89.35987	O-H, (1390-1310), Medium, Bending, Phenol
1457.38909	81.26870	C-H, (1465), Medium, Bending, Alkane
1707.12073	80.34928	C=O, (1720-1706), Strong, Stretching, Carboxylic acid
1744.39411	68.23002	C=O, (1750-1735), Strong, Stretching, Esters
2851.41345	69.34500	C-H, (3000-2840), Medium, Stretching, Alkane
2922.23286	58.61679	C-H, (3000-2840), Medium, Stretching, Alkane
3007.96163	94.03888	O-H, (3200-2700), Weak, Stretching, Alcohol

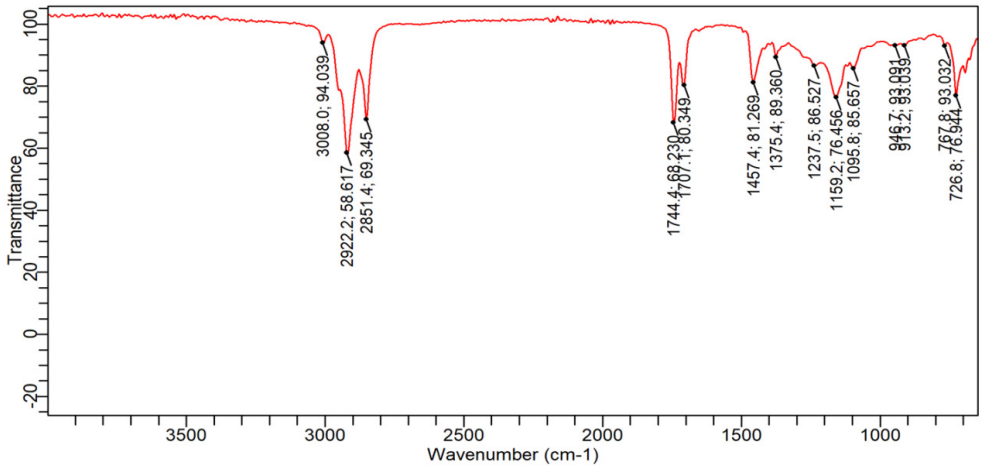

Figure 9: FTIR Spectra for *Hura crepitans* Oil (HCO)

FTIR Result of DRO, JCO and HCO

Extracts

Fourier transform infrared spectroscopy, illustrated in Figures 7–10 and outlined in Tables 7–9, identifies functional groups in *Delonix regia, Jatropha curcas, and Hura crepitans* oils. *Delonix regia* oil contains alkyl halides, alkanes, alkenes, carboxylic acids, ethers, halogen compounds, and cyclopentane. *Jatropha curcas* oil features alkenes, tertiary alcohols, amines, alkanes, sulfur compounds, and esters, while *Hura crepitans* oil includes alkenes, secondary alcohols, benzene derivatives, amines, phenols, esters, and carboxylic acids. These results offer insights into their chemical composition and potential uses.

Conclusion

The rising demand for edible and industrial oils has spurred research into alternative sources, particularly underutilized local plant seeds. Such studies focus on examining their oil content and physicochemical properties to assess their quality, value, and potential as versatile industrial feedstocks. This study evaluated and compared oils from Niger Delta plant species—*Delonix regia*, *Jatropha curcas** and *Hura crepitans**—to the well-established Cocos nucifera* oil, focusing on oil yield and physicochemical properties. The seed oil contents for **Delonix regia**, **Jatropha curcas**, and *Hura crepitans* were 8.4%, 61.0%, and 37.0%, respectively, with corresponding densities (g/cm^3) of 0.86, 0.89, and 0.88 and viscosities (mPa.s) of 11.8, 30.04, and 11.9. Saponification values (mg KOH/g) were 117.81, 277.85, and 174.99. GC-MS and FTIR analyses detected notable organic compounds and functional groups in the oils. These findings highlight the unique characteristics and potential applications of the extracted oils compared to Cocos nucifera oil.

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