

Production of biodiesel from non-edible *Parkia biglobosa* oil under acidic condition

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Abstract

In this study biodiesel was produced from *Parkia biglobosa* via optimization of transesterification reaction condition (methanol to oil ratio, catalyst concentration, reaction temperature and reaction time) under sulphuric acid catalyst (H_2SO_4). Oil was first extracted from *Parkia biglobosa* seeds using soxhlet extraction method. The physico-chemical properties of the biodiesel were analysed and then compared to international standards. Subsequently, the oil was then used to produce biodiesel at optimized transesterification reaction conditions. At the end, the free fatty acid (FFA) content of the oil was 1.61% w/w while the saponification value (mgKOH/g) was 191.65. The maximum yield (percentage weight) of the biodiesel produced was 93.4% at the maximum transesterification conditions of methanol to oil molar ratio of 6:1, sulphuric acid catalyst amount of 3 wt %, reaction temperature of 65°C and reaction time of 1.5 h. When compared with other international standards the biodiesel produced was found to be within the limits of the specification by ASTM D6751 (American standard), EN 14241 (European Standard) and Ghana Standard Authority. It was therefore recommended that biodiesel from *Parkia biglobosa* seed oil under acidic catalytic condition is a potential new non-edible substitute for petroleum diesel for commercialization purposes.

1. Introduction

Petroleum-based fuel performs a crucial function in the energy sector. Petroleum is used principally in the transport sector, specifically in motor engines to run vehicles and power plants. This resource is however, running out (Othman et al., 2017; Fadhil et al., 2019). Global warming is also becoming a concern as a result of anthropogenic activities such as burning of fossil fuels. There are however, significant efforts and interest to explore for renewable, sustainable and energy-friendly fuel sources (Unglert et al., 2020; Yu et al., 2020). There is no doubt that renewable energy sources could provide the much-needed reprieve from the over utilisation of petroleum products.

Research has been extensively carried out on new, renewable energy sources in the quest of fulfilling the world's ravenous energy demand. The new substitute sources of energy include solar, wind, biomass among others. Biodiesel has become one of the most preferred forms of liquid fuel. Biodiesel can however, be compared in terms of characteristic to conventional petroleum diesel. It is renewable and produces minimal emissions after combustion as compared to petroleum diesel. It could revolutionise into a sustainable fuel source (Demirbas, 2009b; Fadhil et al., 2020).

Biodiesel is produced through chemical processes such as transesterification with alcohol that are short-chain including methanol, butanol and ethanol (Takase et al., 2014; Takase et al., 2015).

The choice of an alcohol takes into consideration of many factors including performance and cost-effectiveness. Ethanol and methanol are however, primarily used as alcohol. Methanol is cheap and has desirable physical and chemical properties. On the other hand, ethanol is friendly to the environment

since it is obtained from renewable source such as corn making the process entirely independent of petroleum-based alcohol (Mujeeb et al., 2016; Fadhil et al., 2020).

Kinematic Viscosity of the oil from plants is supposed to be lowered to enhance its utilisation in diesel engine. Various methods have been developed to reduce oil's viscosity. The methods are blending with diesel, transesterification, pyrolysis and micro emulsification (Axelsson et al., 2012; Borugadda & Goud, 2012). Blending and transesterification however, remain the most popular methods. Meanwhile, among the two, transesterification remains a more superior and efficient method of reducing vegetable oil's viscosity and yielding fuel with similar diesel properties (Refaat & Refaat, 2010; Hassan, 2021).

Transesterification entail the use of catalysts such as alkali, acids, or enzymes for biodiesel. Homogenous catalyst exists in the same phase (either gas or liquid) as the reactants. Typical case of homogenous include sulphuric acid, sodium hydroxide and many others. Alkali catalysts are mostly preferred due to its practical and industrial feasibility. They are also less costly, unlike enzymes. Glycerol as the backbone of the reaction process is essential component in soap-making and cosmetic industries (Altikriti et al., 2015).

In this study *Parkia biglobosa* is been used. In Ghana, biodiesel is being produced from edible oils such as rape seed, soybean oil and castor. However, recent studies by Takase et al. (2015) revealed that there are a lot of alternative non-edible high oil yielding crops that can be considered as resources. One of the new and promising non-edibles is *Parkia biglobosa* oil, which is gaining popularity in medicinal and pharmaceutical studies but very scanty in terms of a resource for biodiesel (Janick & Paull, 2008; Abioye et al., 2013; Kipkoech 2021).

Parkia biglobosa, a member of the Fabaceae family is widely grown in Ghana. The key Regions that grow the plant are Northern, Oti and Volta (Kipkoech, 2021). The active components of the plant have been exploited for medicinal and pharmaceutical purposes (Janick & Paull, 2008; Abioye et al., 2013). Typically, the extract obtained from the leaves and seeds can be used to treat liver diseases (Ojewumi, 2016). Current studies have shown that the seeds from the plant contain a lot of oil (Olowokere et al., 2018). According to studies by Olowokere et al. (2018), the amount of oil per seed could be more than 11.4%. In addition, at *Parkia* industrial oil production in Volta Region Ghana, the oil is seen by-product and goes waste with little used. The purpose of this study was henceforth to investigate biodiesel production from *Parkia biglobosa* seed oil using efficient and economical sulfuric acid catalyst.

2. Materials And Method

2.1 Instrument

The instruments used in the experiments were; soxhlet extractor, 250 ml round bottom flask condenser, heating mantle, oven (DGH-9140A, YIHENG), furnace, GC Mass Spectrometry (GC-MS,7890A Agilent Technology Inc. USA) and rotary evaporator (BÜCHI rotavapor).

2.2 Reagents and Materials

Laboratory equipment and chemicals that were employed to the experiment included; petroleum ether purchased from Ryht Aid Chemicals (Ho), electric grinder, 250 ml conical flask, condenser, magnetic stirrer, methanol of purity 98%, and 5%(w/w) H₂SO₄ obtained from School of Biological Science Stores at the University of Cape Coast.

2.3 Experimental

2.3.1 Sample Collection and Preparation

The collection of *Parkia biglobosa* seeds were done during the harvest season at Dambai in Oti Region. The samples of the seed were screened and thoroughly cleaned to ensure the elimination of dirt and seeds that have been destroyed for example by insect. Dehulling, was carried through removal of the outer covering of the seed, washing, and then sun-dried and subsequently ground. The seeds were ground using an electric grinder into particle size and put into an airtight Teflon-lined container before extraction.

2.3.2 Extraction of *Parkia biglobosa* and Determination of Percentage Yield

Parkia biglobosa oil was extracted using petroleum ether (40–60°C) by adopting Olowokere et al. (2019) recommended method. Extraction of oil was done using a soxhlet apparatus and petroleum ether as the extraction solvent. A ratio of 12:1 of solvent to seed was applied for extraction. 250 ml of the petroleum ether was poured into a round bottom flask while ground *Parkia biglobosa* seed weighing 25 g was kept in a filter. The filter containing the seeds was then carefully placed inside the thimble, fixed to the round bottom flask on top of the heating mantle, and connected to the condenser. The heating mantle was switched to heat the solvent (Kipkoech, 2021).

The heated solvent in a conical flask began to boil and change to vapour and subsequently condensed to liquid by condenser. The extraction process was done in 5 h (Suwari *et al.*, 2017; Olowokere et al., 2018). Extracted *Parkia biglobosa* oil was then dried, recorded, and subjected to the degumming process by treating it with hot water to eliminate any hydrates, gums, phosphate and other impurities. The content of the oil was determined using Takase et al. (2014) method.

2.3.3 Composition and characterization of the feedstock

The content of the oil was analysed using Takase et al. (2014) recommended method with little modification. Specifically, a thermal conductivity detector (TCD) was fitted to GC-MS and a high-polarity general purpose column recommended for Free Fatty Acid and Phenols (15% FFAP, Chromosorb W, A/W 80/100, Length of 2m). Helium at high purity of 99.9999% used as the carrier gas. Column operation temperature range of 50°C-250°C and sample inlet temperatures of 200°C were used. The oven ramp temperature was initially kept at 60°C for 5 min and thereafter increased to 220°C at 10°C/min for 10 min. Sample inlet pressure (Carrier gas 20ml/min) and total pressure with makeup (Carrier gas and

makeup 21ml/min) were used. The temperature of the detector was 250°C. Analysis and characterization of *Parkia biglobosa* oil was done using Takase et al. (2014) recommended method.

2.4 Transesterification Reaction

The process of transesterification reaction of triglyceride to biodiesel was done using 20 g of the extracted *Parkia biglobosa* oil by initially filling into a 250 ml conical flask in a heating mantle connected with condenser and magnetic stirrer. Weight of the oil was measured and recorded before heating to the standard temperature of 60°C. Methanol was then mixed with 4wt.% of H₂SO₄ and the solution added to the oil. The methylolysis of triglyceride to biodiesel was done at varying methanol to oil ratio of between 5:1, 5.5:1, 6:1, and 6.5:1. The time of reaction was varied from 0.5 h to 2 h, the temperature of the reaction from 55°C, 60°C, 65°C, and 70°C and the amount of catalyst from 1–4% (weight of the oil). The yield of biodiesel was done using Takase et al. (2014) recommended method.

2.5 Determination of Biodiesel Properties

The samples of biodiesel were analyzed using ASTM D6584 method (Takase *et al.*, 2024) with little modification. Thus, a thermal conductivity detector (TCD) was fitted to GC-MS and a high-polarity general purpose column recommended for Free Fatty Acid and Phenols (15% FFAP, Chromosorb W, A/W 80/100, Length of 2m). Helium at high purity of 99.9999% used as carrier gas. Column operation temperature ranged from 50°C to 250°C and sample inlet temperatures of 200°C was used. The oven ramp temperature was initially kept at 60°C for 5 min and thereafter raised to 220°C at 10°C/min for 10 min. Sample inlet pressure (Carrier gas 20ml/min) and total pressure with makeup (Carrier gas and makeup 21ml/min) were used. The temperature of the detector was 250°C.

The physic-chemical properties of the biodiesel were analyzed using ASTM 6751 method and Europe Standard (14214) as in Takase et al. (2014). The proper analysed include; density at (20°C), kinematic viscosity, acid value, water/moisture content, flash point, cold flow properties, cetane number, ash content, sulphur content, free glycerine, total glycerine, Oxidative stability at 110°C/h, Cold filter plugging point (°C), Iodine value g/100, Copper strip corrosion (50 °C; 3 h) (Kipkoech, 2021).

3. Results And Discussion

3.1 Physico-chemical Characterization of *Parkia biglobosa* Oil

From results of the study, the stearic acid for the analyzed *Parkia biglobosa* oil was 4.30%, while the reported *Parkia biglobosa* oil was 5.3%. The variation in the percentage of stearic acid in this study was slightly low. Similarly, linoleic acid for both the *Parkia biglobosa* oil that was analyzed and the one reported was 65.42% and 63.5%, respectively. The fatty acid composition of the obtained oil was similar to the study by Augustine et al. (2013) as in Table 1.

Table 1
Fatty Acid Composition of *Parkia biglobosa* Oil

Fatty Acid Composition	Analysed Value (%)	Reported by (%) (Augustine et al., 2013)
Palmitic acid (16:00)	15.08	5.0
Stearic acid(C18:0)	4.30	5.3
Oleic acid(C18:1)	7.90	12.5
Linoleic acid(C18:2)	65.42	63.5
Arachidic acid(C20:0)	5.21	-

The difference in palmitic acid in both oils agrees with the research by State (2020). In his research, State (2020) alluded that the differences in the chemical composition of similar oil were due to difference in locations where the oil was obtained. Some of the key factors such as soil type and climatic conditions were proven to affect the properties of the oil. Furthermore, these findings are comparable with those in research by Lin & Lin (2012), which found out that C16:0, C18:2 and C18:1 form the three main compounds. Furthermore, it was revealed that individual kinetics for the three acids mentioned are useful, especially in situations where the composition of FFA is higher, it will result in the biodiesel that has highest saturated fatty acid, and hence huge thermal and oxidative stability (Gaurav et al., 2019). When compared with Augustine et al. (2013), Arachidic acid (5.21%) in this study was relatively high.

3.2 Properties of *Parkia biglobosa* oil

Parkia biglobosa oil was analysed for physicochemical properties which include density, kinematic viscosity, water content, average molecular weight, and free fatty acid.

Table 2
Properties of *Parkia biglobosa* Oil Used as Feedstock for Biodiesel Production

Property	Testing procedure	ASTM Std.	Ghana Std. Authority	Determined value
Density at 20°C (Kg/m ³)	ASTMD4052-96	860–890	870–900	916.2
Saponification value (mgKOH/g)	ASTMD4052-96	191–202	-	191.65
Kinematic viscosity at 40 °C, mm ² /s	ASTMD 445-06	1.9–6.0	1.5–6.5	35.70
Water content (%) w/w	AOAC 984.20–90	0.05 max	0.05 max	1.93
Free fatty acid content (%) w/w	AOAC 940.28	-	-	1.61

Method used for analysis were as outlined by the Association of Official Analytical Chemists (2005) (Aransiola, et al., 2010) and American Standard for Testing Material (ASTM). Based on the data, *Parkia biglobosa* oil has a high density of 916.2 kg/m³ and kinematic viscosity (35.70 mm²/s) at 40°C.

Denser of oil produces a higher amount of energy (Tabatabaei et al., 2019). Biodiesel's relative density is important in mass to volume conversion and determines the flow and viscosity of properties. It is also helpful in the determination of the homogeneity of biodiesel. The saponification value as per the analysis of the *Parkia biglobosa* oil was 191.65 (mgKOH/g). The saponification value from the analysis still falls within the limit outlined by ASTM4052-96. *Parkia biglobosa* oil contained high FFA of 1.61% and high-water content of 1.93(%) w/w.

Fatty acid and moisture content are crucial parameters in determination if oil are recommended for transesterification process. Feedstocks containing high free fatty acid (> 0.5%) cannot be converted easily by base catalyzed transesterification as a result of concurrent formation of soap. That challenge was avoided through carrying out transesterification using sulphuric acid catalyst (Mishra & Goswami, 2018; Suraj et al., 2020). From the results it was revealed that *Parkia biglobosa* oil was ideal for biodiesel production.

3.3 Optimization of Reaction Parameters

3.3.1 Methanol to oil ratio

From Fig. 1, there was a gradual increase in biodiesel yield from 78.9–90.7% as the ratio of methanol to oil was adjusted upwards from 5:1 to 6:1, respectively. Optimization was carried out to determine the optimum biodiesel yield (90.7%) which was attained at the ratio of 6:1. There was a decrease in the biodiesel yield 90.7–88.7% at the ratio of methanol to oil of 6.5:1. This was possibly due to an increasing

molar ratio which leads to low segregation of glycerol and biodiesel due to high solubility. According to Lee & Saka (2010), alcohol to oil molar ratio is one of the crucial factors that affects the efficient methanolysis of oil to biodiesel and the cost of production. The results of this study is similar to Kipkoech (2021) studies on Production of Biodiesel from *Parkia biglobosa* oil using heterogeneous bi-functional clay catalyst. In Kipkoech studies, the optimum methanol to oil ratio was 6:1 with a yield of 90.7%. The transesterification stoichiometric ratio of alcohol to oil is 3:1. Greater ratios are needed since the reaction is reversible (Miao & Wu, 2006).

Shifting the reaction to the completion side means the ratio is supposed to be higher than the stoichiometric ratios. Breaking glycerine-fatty acid bonds in transesterification reaction of glyceride to form biodiesel needs extra alcohol (Miao & Wu, 2006). Thus, a greater ratio of alcohol to oil leads to converting the large amount of alkyl ester within a short period (Helwani et al., 2009). This is supported by study by Eevera et al. (2009). Oil from non-edible including pongamia and neem needs much alcohol to yield maximum amount of biodiesel. This is due to the high viscosity of the non-edible oil as compared to edible ones (Eevera et al., 2009).

3.3.2 Reaction temperature

The influence of the temperature of the reaction was examined (Fig. 2). The synthesis of biodiesel by methanolysis of *Parkia biglobosa* seed oil was achieved through variations of the reaction temperature (55°C, 60°C, 65°C and 70°C). As the reaction temperature was adjusted upward from 55°C to 60°C, it led to a slight rise in the yield of biodiesel from 76.6 % to 77.0 %, respectively. However, a sharp rise in biodiesel yield from 77.0 % to 88.5 % occurred when reaction temperature was increased from 60°C to 65°C and decreases from 88.5% to 76.5%. Therefore, the optimized reaction temperature for transesterification of *Parkia biglobosa* oil was 65°C. The yield at reaction temperatures below and above 65°C were low. At 55°C and 60°C, the reaction was not complete. At reaction temperature above 70°C, the methanol starts to burn entirely as some vaporize and formed bubbles. Since methanol undergoes melting at a temperature between 60°C and 65°C, the reaction interface is inhibited. These findings are in line with those of Borugadda & Goud (2012) which noted similar observation on the vaporization of methanol at 70°C and the formation of bubbles. Furthermore, it was noted that at 70°C the reaction was still not complete. This observation could be because of slight increase in viscosity of the oil which results in oil and catalyst mixing poorly (Liu et al., 2008; Kipkoech, 2021).

3.3.3 Effects of catalyst concentration

1%, 2%, 3%, and 4% wt (weight) of the sulphuric acid concentration (with reference to the oil's weight) was used (Fig. 3). Initially, there was a sharp increase of biodiesel from 81.3–93.4% as the amount of catalyst was raised from 1wt % to 3 wt %. The optimum yield of 93.4% was attained by using 3 wt % of the catalyst. A sharp decline in the biodiesel yield (88.5%) was noted as the catalyst concentration was increase to 4wt %. Studies by Mathiyazhagan & Ganapathi (2011) showed similar trends. They highlighted that, the rates of reaction in acid-catalysed transesterification reaction can lead to attainment

of a higher yield of biodiesel by using a higher amount of catalyst. Increasing concentration of catalyst results in more active sites for the methanolysis of available triglyceride. Additional upward adjustment in catalyst concentrations (above 4wt.%) resulted in slight reduction in the yield (Kipkoech, 2021). This could be as results of the formation of soap (Fig. 3).

Canakci & Van Gerpen (2001) studied methanolysis of grease using methanol with varied sulphuric acid concentration (1, 3 and 4% wt). The study explored the rate of enhancement of rise in level of catalyst concentration and the consequent yield of biodiesel. The optimum yield obtained in their work was 95.0%.

3.3.4 Effects of Reaction Time

Transesterification reactions depend on time. At 0.5 h, the yield of biodiesel was 90.0% (Fig. 4). The reaction was however, slow and this could be attributed to insufficient stirring which could not enhance adequate mixing and dispersion of methanol and oil (Sharma et al., 2008). Contrastingly, between 0.5 h and 1 h, a constant rise in the amount of biodiesel was obtained (90.0–91.9%). It was then preceded by a rise in yield of biodiesel (93.0%) at 1.5 h of the reaction time and this was an optimum yield.

As the time was prolonged from 1.5 h to 2 hrs, biodiesel's amount decreased from 93.0–90.5%. The reduction in the quantity of biodiesel obtained is as a result from the occurrence of a reversible reaction. The findings are similar to Takase et al (2014) findings on the influence of time on acid-catalysed transesterification which resulted in high amount of biodiesel produced (maximum) as the time of the reaction was increased. In the beginning, the slow rate of reaction could be as a result of poor mixing of methanol, oil and the catalyst interface. Nevertheless, optimum production of biodiesel was reached in less than 1.5 h. This shows the optimum amount of biodiesel from *Parkia biglobosa* seed oil was attained after a considerable time while using H_2SO_4 catalyst. When compared with other oil which can produce optimum yield of biodiesel within a short time, the yield in this case is relatively low (Takase et al., 2014). Further rise in the time of the reaction did not lead to a rise the yield of biodiesel (Leung & Guo, 2006; Alamu et al., 2007). Further upward adjustment in reaction time led to the reduction in the amount of biodiesel produced and was possibly due to backward reaction (Eevera et al., 2009; Takase et al., 2014). This same trend was observed by Kipkoech (2021) in transesterification of *Parkia biglobosa* oil to biodiesel using sulphur acid as catalyst under the same reaction condition (molar ratio of methanol to oil 6:1, reaction temperature $65^{\circ}C$ and catalyst concentration 3wt%).

3.3.5 Characterization of *Parkia biglobosa* seed oil and biodiesel

The FTIR patterh of *Parkia biglobosa* oil and its biodiesel is indicated in Figs. 5 and 6 respectively. There appeared a broad band at 3344 cm^{-1} of the oil. However, in the biodiesel the broad band was weak and appeared at 3546 cm^{-1} and this could be attributed to the stretching vibration of the biodiesel. The band at 1663 cm^{-1} for the oil and 1446 cm^{-1} for the biodiesel was ascribed to the stretching vibration of –

CH₂. The bands at 1369 cm⁻¹ and 1017 cm⁻¹ for oil and biodiesel respectively was ascribed to vibration in the oil and biodiesel and the band at 1002 cm⁻¹ of oil and 860 cm⁻¹ of the biodiesel was due to –C = O stretching vibration. The peak at 702 cm⁻¹ of the biodiesel was due to shear-type vibration. The bands at between 463 and 1002 cm⁻¹ for the oil and between 459 and 590 cm⁻¹ for biodiesel were due to the vibration of C-O-C group (Kipkoech, 2021).

3.3.6 Properties and application feasibility of *Parkia biglobosa* biodiesel

Physical and chemical properties for the biodiesel prepared from *Parkia biglobosa* seed oil using sulphuric acid as a catalyst are within the acceptable standards (Table 3). The international standards used were ASTM D6751 and EN14214 and Ghana Standard Authority which describe biodiesel's testing parameters and limits. Density and kinematic viscosity are crucial properties because they affect the performance of the engine. Fuel with higher density has greater mass and more viscous one has a low flow rate which influences the engine's output. Kinematic viscosity freely the fuel flow into the injection during the combustion process. In study, the viscosity of the oil was greatly reduced by 88.5% (from 35.70 to 4.1 mm²/s) in the biodiesel obtained. The oil's density was 916.2 kg/m³ and that of the biodiesel was 868 kg/m³ (Kipkoech, 2021).

Iodine value represents the degree of unsaturation of biodiesel. There is a significantly high level of iodine value (137 g/100) in the biodiesel which was above the limit for the acceptable standard; thus, both ASTM Std.D6751 and EN 14214. According to Costenoble et al. (2008), manufacturers of engine for a long time have been arguing that high value of iodine possibly causes polymerization and formation of deposits on the engine nozzles, piston rings and piston ring grooves during heating. There was 0.093% (w/w) water content in the oil which was not within ASTM StdD6751 of 0.05 as maximum. Water content in the biodiesel was 0.07 mg/kg which was slightly higher than ASTM Std.D6751 and EN 14214 standard as well as Ghana Standard Authority of 0.05 mg/kg maximum. The other properties including cetane number, viscosity, flash point and so forth were within international standards (Kipkoech, 2021).

Table 3

Properties of *Parkia Biglobosa Biodiesel* as Compared to Standards of Europe, United States and Ghana
Standard Authority

Property	Method	ASTM Std. D6751	EN 14214	Ghana Std. Authority	Determined value
Cetane number	ASTM D6890	≥ 47	≥ 51	47 min	51
Kinematic viscosity (mm ² /s; 40 °C)	ASTM D445	1.9-6.0	3.5-5.0	1.5–6.5	4.1
Oxidative stability (h)	EN 14112	≥ 3	≥ 6	-	3.1
Cloud point (°C)	GB/T510	-15 to 16	-	-	-1
Pour point (°C)	GB/T3535	-3 to 12	-	+ 15 max	-1
Flash point (°C)	ASTM D93	≥ 93	≥ 120	66 min	155
Sulfur content (% w/w)	ASTM D4294	≤ 0.05	0.020	0.05 max	0.004
Ash content (% w/w)	GB/T508	≤ 0.02	≤ 0.02	0.1 max	0.019
Acid value (KOH mg/kg)	ASTM D664- 01	≤ 0.5	≤ 0.5	1.0 max	0.456
Water (mg/kg)	D6304	≤ 0.05	≤ 0.05	0.05 max	0.07
Density (20 °C)	SH/T0248	-	860– 900	-	868
Iodine value g/100	EN 14111	≤ 120	≤ 120	-	137
Copper strip corrosion (50 °C, 3 h)	ASTM D 130 – 94	≤No.3a	≤No.1a	-	1 a
Free glycerine (% w/w)	EN 1405	≤ 0.02	≤ 0.020	-	0.002
Total glycerine (% w/w)	SH/T0796	0.24	≤ 0.25	-	0.16
Source: Lab analysis (2021)					

4. Conclusion

Parkia biglobosa oil was obtained by subjecting the *Parkia biglobosa* seed to the soxhlet extraction. The percentage yield of the oil was 16.5%. Properties such as fatty acid compositions, water content,

saponification value and many others of the oil as required were within acceptable limit for producing biodiesel. From the study, the following can be concluded: The highest biodiesel yield from *Parkia biglobosa* oil through transesterification with sulphuric acid catalyst was achieved at ratio of methanol to oil of 6:1, temperature of reaction of 65°C catalyst concentration of 3 wt % in 1.5 h. The optimum biodiesel yield was 93.4% (Kipkoech, 2021). The key properties of the obtained biodiesel were within United States of American Standard (ASTM D6751), European Standard (EN14241) and Ghana Standard Authority. On the bases of the yields and the properties of the biodiesel as comparable to international standards complement with the abundance of *Parkia biglobosa* oil and at *Parkia* Industrial production as by-product in Ghana, the oil could be seen as a potential non-edible feedstock for biodiesel, particularly in Ghana.

Declarations

Data availability statement

Data used for the research is embedded within the manuscript.

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Disclosure statement

The authors declare that there are no conflicts of interest.

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Figures

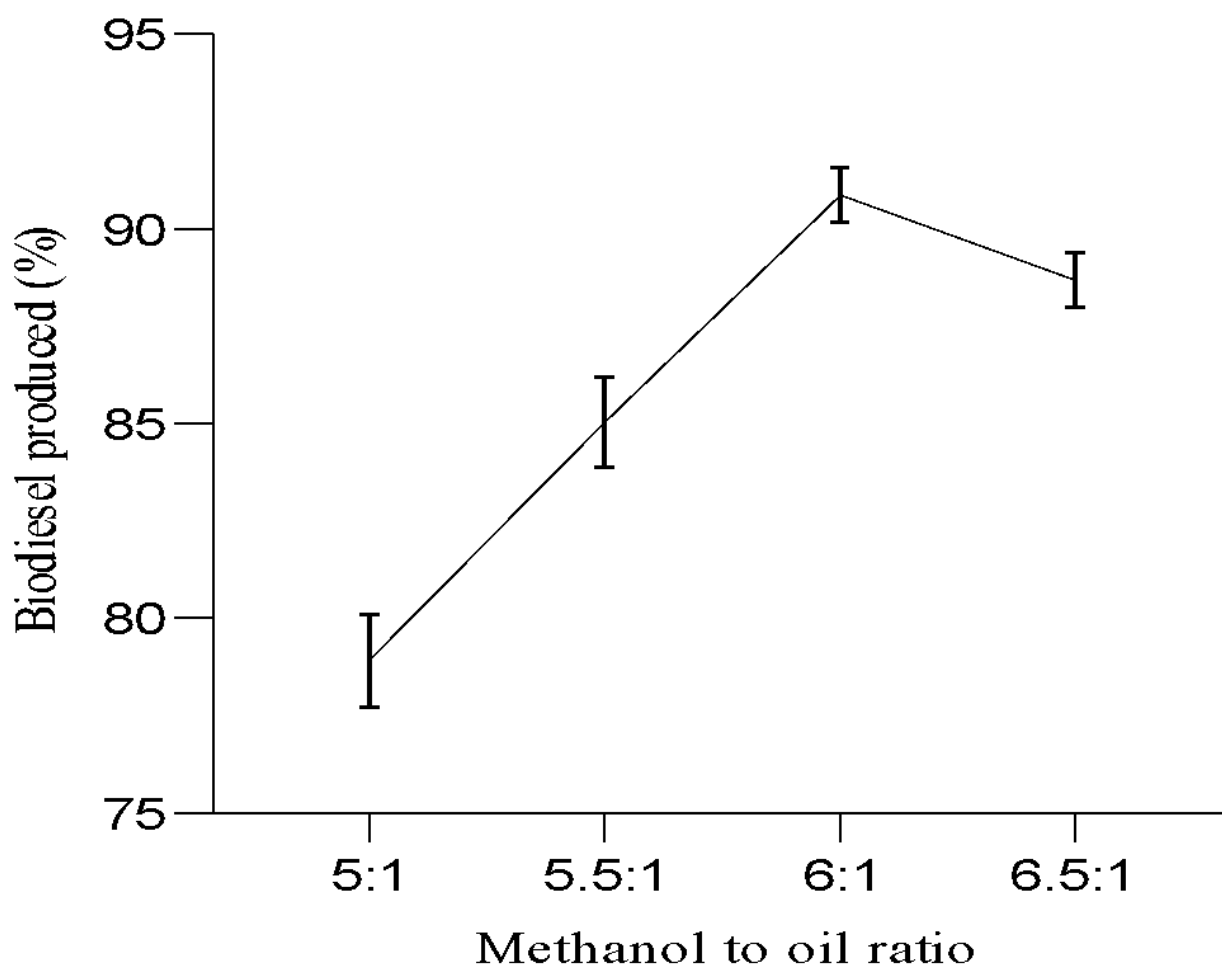


Figure 1

Influence of Methanol to Oil ratio on Production of Biodiesel (Reaction Temperature 60°C, Catalyst Concentration 1%wt and Reaction Time 1 h) Mean with Standard deviation values were; 78.93±1.18, 85.07±1.16, 90.9±0.7 and 88.70±0.7

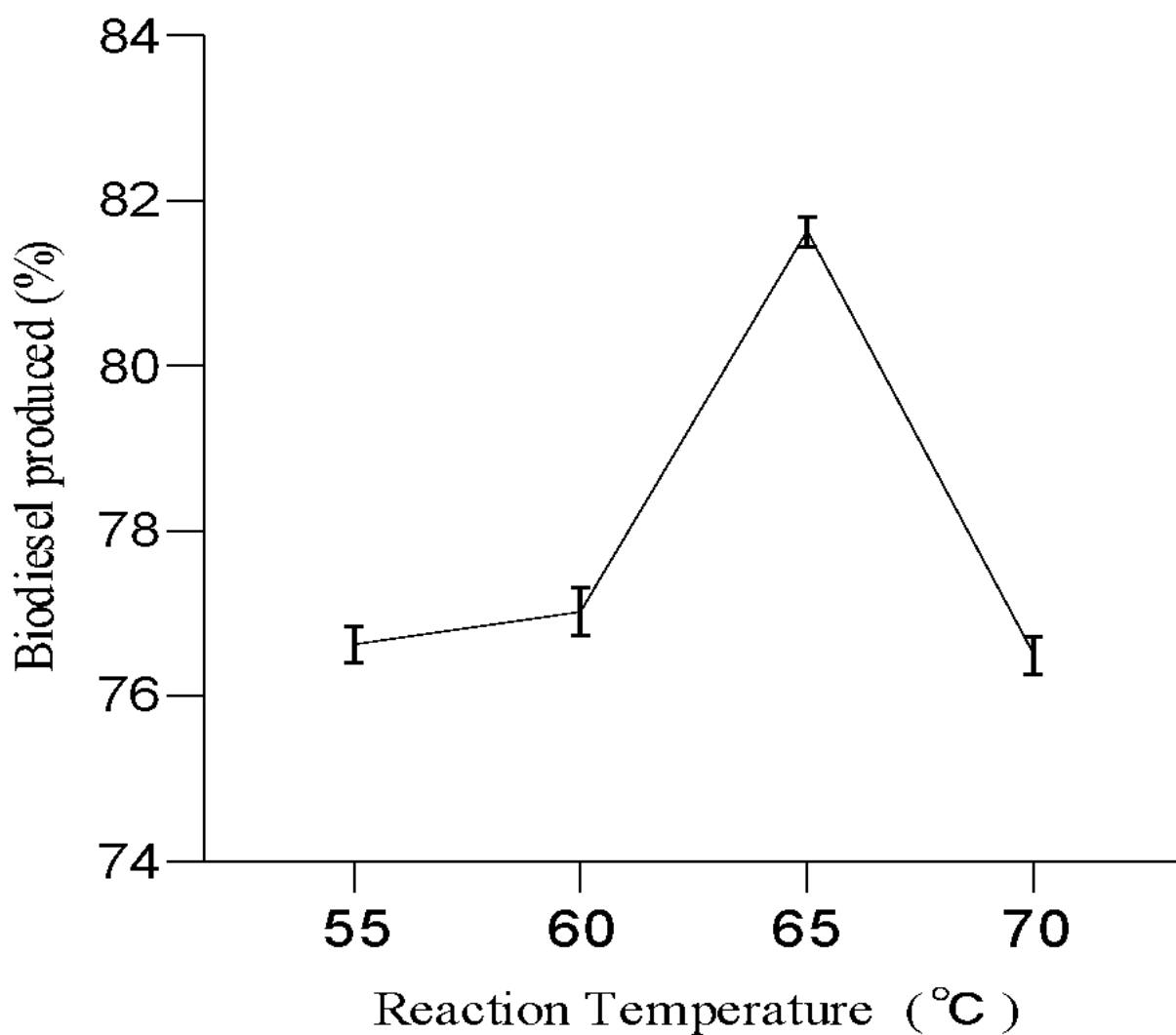


Figure 2

Influence of Reaction Temperature on Production of Biodiesel (Molar ratio of Methanol to Oil 6:1, Catalyst Concentration 1 %wt and Reaction Time 1 h) Mean with Standard deviation values were; 76.63 ± 0.38 , 77.03 ± 0.49 , 81.63 ± 0.31 and 76.5 ± 0.4

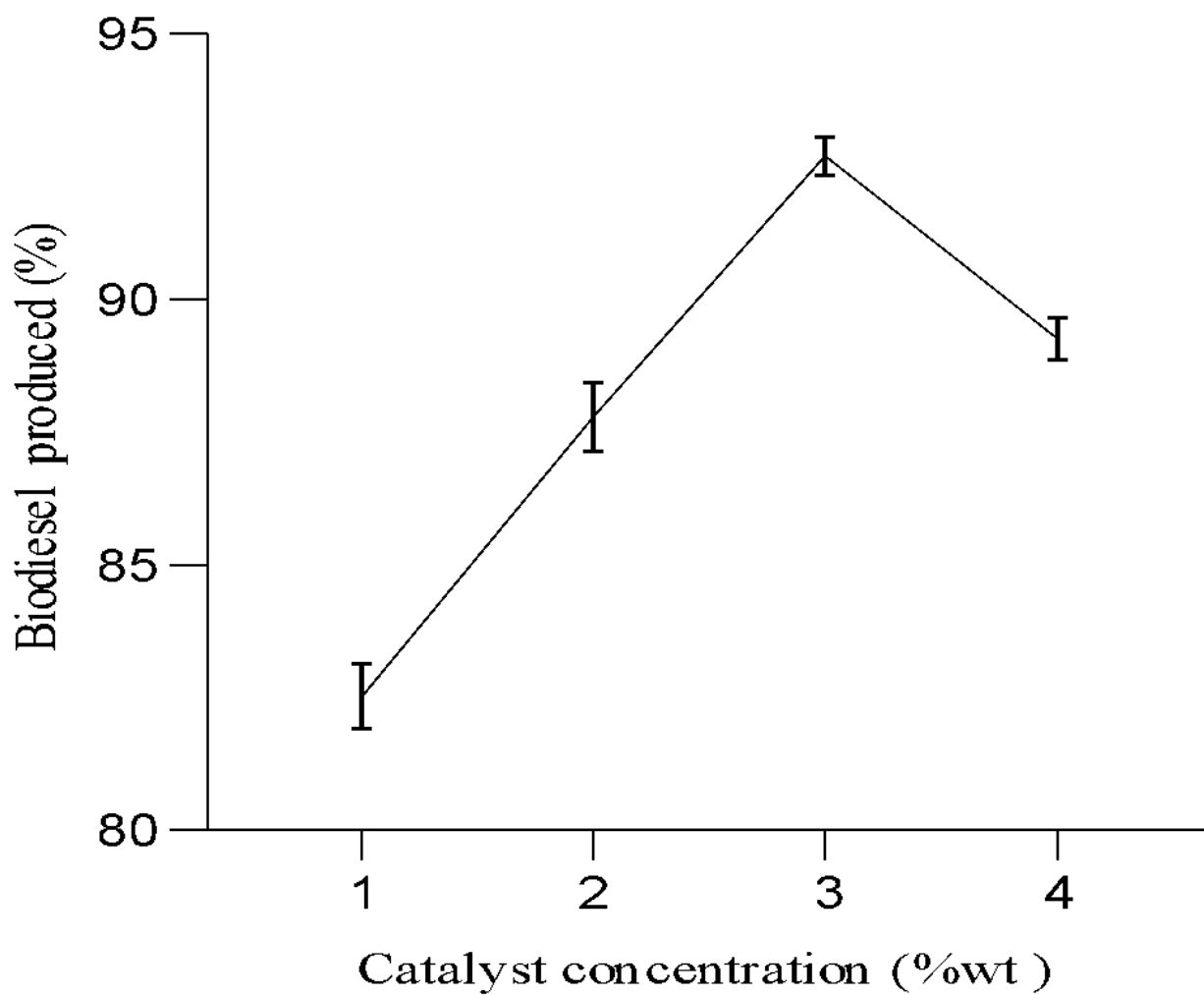


Figure 3

Influence of Catalyst Concentration on the Production of Biodiesel (Molar ratio of Methanol to Oil 6:1, Reaction Temperature 65°C and Reaction Time 1 h) Mean with Standard deviation values were; 82.53±1.07, 87.80±1.13, 92.70±0.61 and 89.27±0.67

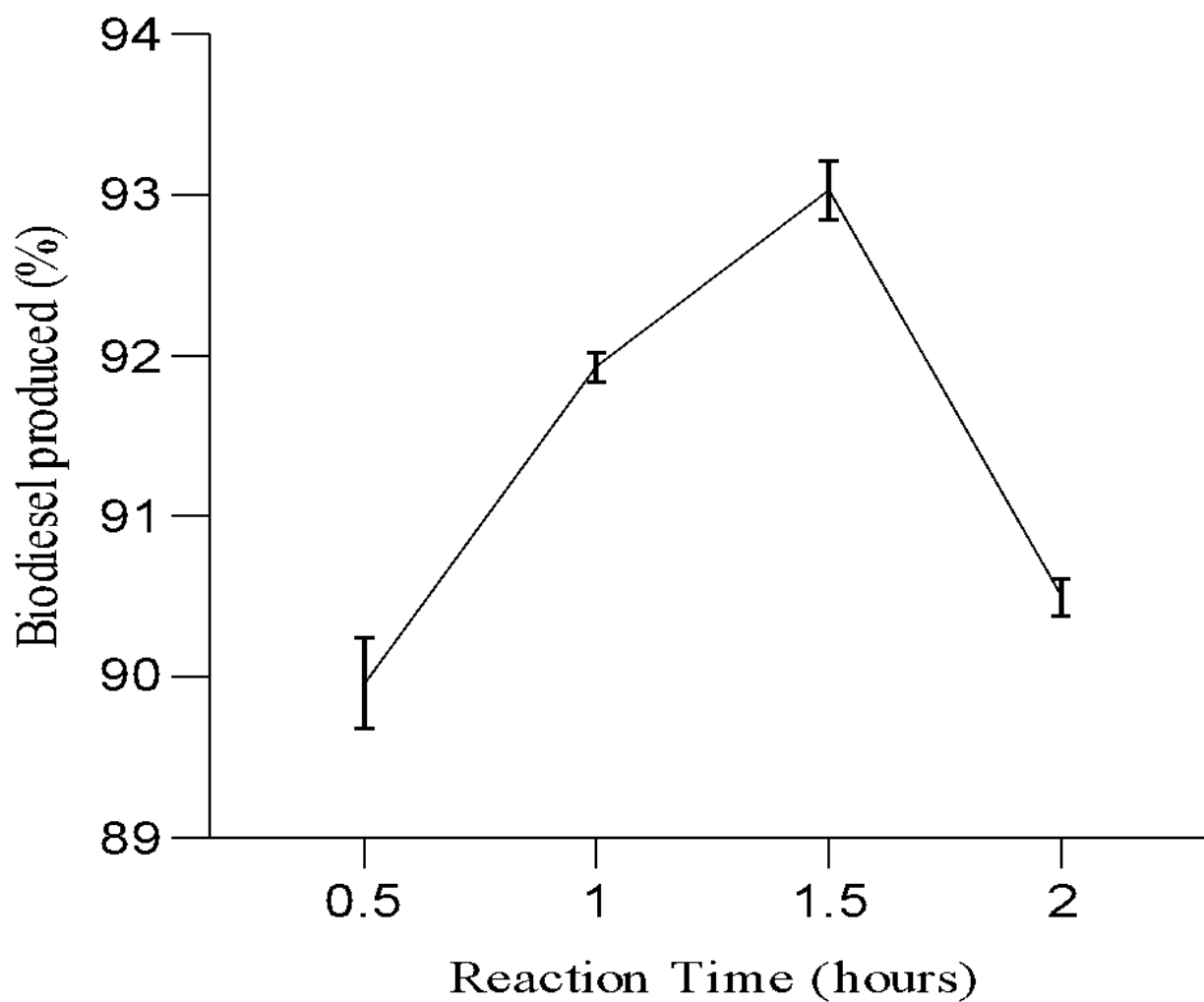


Figure 4

Influence of Reaction Time on the Production of Biodiesel (Molar ratio of Methanol to oil 6:1, Reaction Temperature 65°C and Catalyst Concentration 3wt%). Mean with Standard deviation values were; 89.97±0.49, 91.93±0.15, 93.03±0.32 and 90.50±0.2.

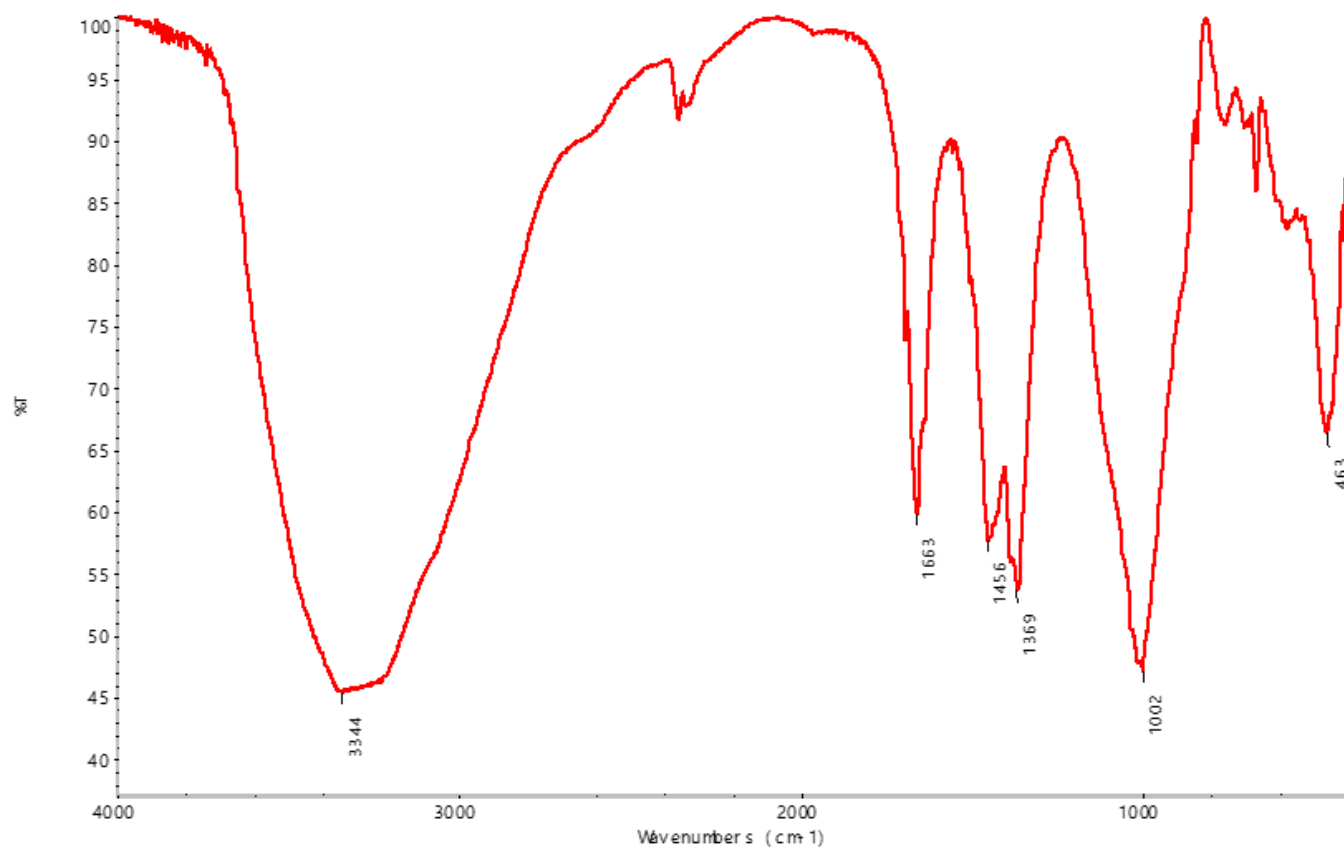


Figure 5

FT-IR Spectrum of *Parkia biglobosa* seed oil

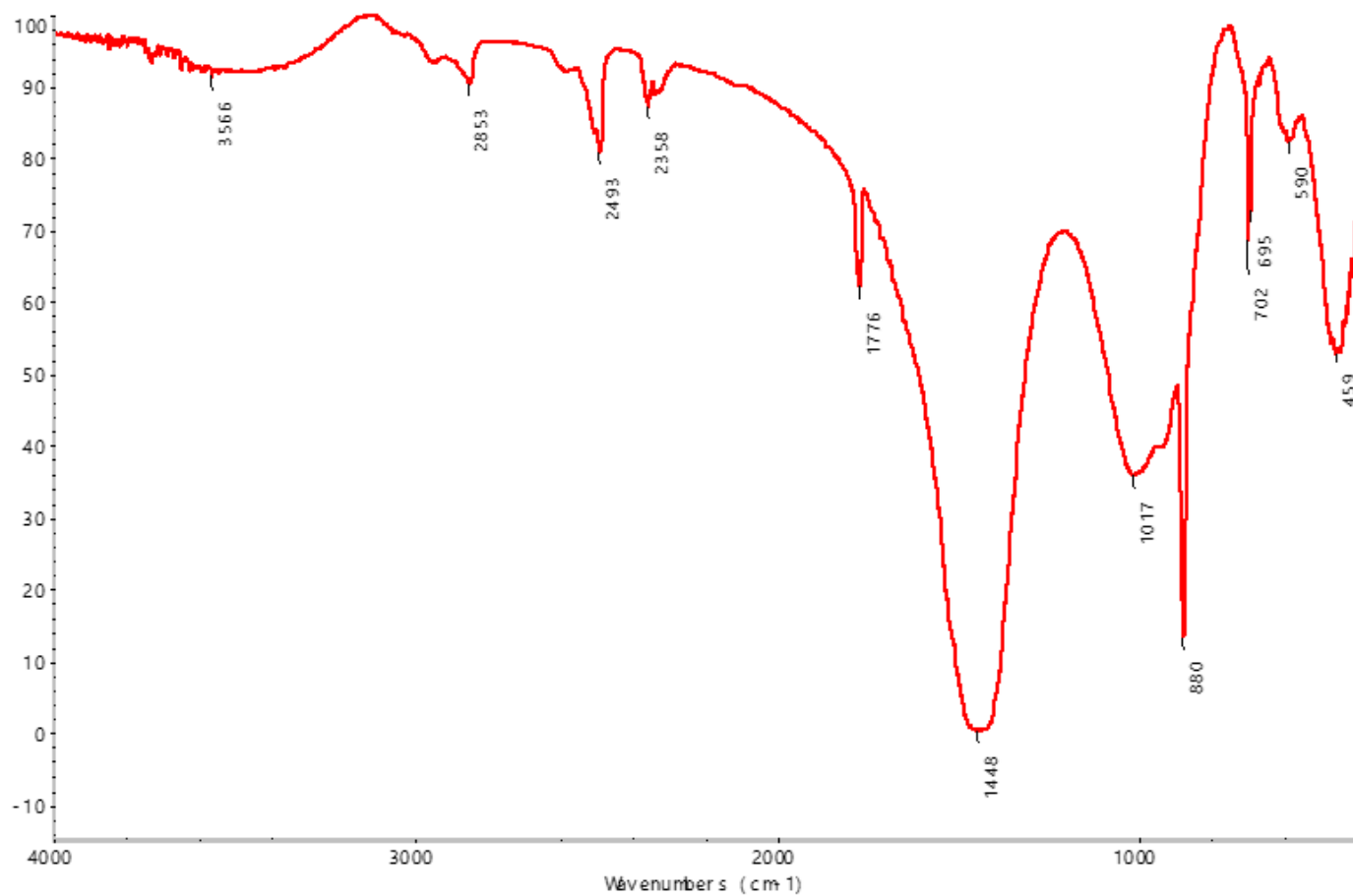


Figure 6

FT-IR Spectrum of *Parkia biglobosa* biodiesel.