Exploring renewable energy sources is crucial in light of the rising demand for sustainable alternatives fuels, particularly in nations like Nigeria that have a wealth of agricultural resources but heavily rely on export of fossil fuels for economic growth. While limited studies has been carried out on the efficiency of biodiesel from tiger nut oil and castor seed oil in diesel engines, a comprehensive spectroscopic analysis of biodiesel produced from palm kernel oil (PKO), tiger nut oil (TGO), and castor seed oil (CSO) was carried out in this research. This study's main goal is to examine the feasibility and efficiency of Palm kernel oil biodiesel (PKOB), Tigernut oil biodiesel (TGOB) and Castor seed oil biodiesel (CSOB), in diesel engines without affecting engine performance. The transesterification process was optimized, the feedstock was characterized, and the biodiesel samples were thoroughly analysed as part of the research methodology. The physiochemical characteristics of PKOB, TGOB, and CSOB were initially identified, offering critical information on their viability as biodiesel feedstocks. For the qualitative examination of the biodiesel samples, Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography-Mass Spectrometry (GCMS) were used. This allowed for identifying the functional groups and the determination of the fatty acid composition. The findings of the examination of the biodiesel samples showed that important functional groups like CH2, CH3, HCH, and C=O were present. The GCMS analysis gave useful information about the fatty acid methyl esters (FAMEs) present in biodiesel, proving that the feedstocks were successfully converted into biodiesel. In addition, the biodiesel samples' iodine value, specify gravity, ash content, cetane number, flash point, cloud point, and heating value were calculated and compared to established standards. The results showed that PKOB, TGOB, and CSOB had desirable characteristics that fell within the ranges required for biodiesel fuel. The results for specific gravity were reasonably close to those of the American Society for Testing and Materials, ASTM D6751 (0.86-0.90), indicating satisfactory flow and combustion properties. Iodine values that were below the maximum limit (120) showed better stability and oxidation resistance.

The ash contents were less than 0.1%, indicating minimal risk of engine deposits. Moreover, the cetane numbes (>130o C), and heating values (>35) demonstrated the potential of the biodiesel samples for efficient combustion and energy content. Overall, this research contributes to the knowledge and understanding of the engine suitability of PKOB, TGOB, and CSOB. The use of FTIR and GCMS analysis techniques provided valuable insights into the composition and quality of the biodiesel samples. The results obtained suggest that biodiesel derived from these feedstocks possesses favourable characteristics for use as a sustainable alternative fuel. This research offers significant implications for the energy sector, promoting the utilization of locally available feedstocks and reducing dependence on fossil fuels.