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UTILISATION OF NON EDIBLE SEED OILS AS POTENTIAL FEEDSTOCKS FOR BIODIESEL PRODUCTION: A REVIEW

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ABSTRACT: *Biodiesel is a promising renewable alternative fuel for diesel engines. Currently edible resources constitute 95% of biodiesel production feedstock. The continuous and large scale production of biodiesel from edible oils has recently been of great concern because they compete with food materials- the food versus fuel dispute. This paper reviewed the prospect of making biodiesel from some non-edible seed oils of Castor, Jatropha curcas, Neem and Yelllow oleander. The review gave physicochemical properties, torque outputs and specific fuel consumptions that are close to those of fossil fuel diesel thus confirming that they can be used as alternative fuels in diesel engines.*

KEYWORDS: biodiesel, transesterification, kinematic viscosity, global warming

INTRODUCTION

Modern economic activities are high resulting to huge infrastructure demand especially energy, particularly liquid fuels for the transport and power sectors or industries. The primary source of liquid fuel is currently crude oil which is becoming harder and more expensive to recover as conventional reserves are depleted and as foreign suppliers increase the price for their declining reserves. With the wide majority of atmospheric scientist now agreeing that global warming is already a global problem, there are now more strident calls to replace crude oil as our liquid fuel source in order to reduce the build-up of greenhouse gases in the environment. Thus an additional emphasis is being placed on the development, production and the use of alternative fuel considered being friendlier to the environment than fossil fuel. Generally, bio-sourced fuels are termed biofuels examples of which are biomethanol, bioethanol, biobutanol, biomethane, biohydrogen, biodiesel etc (Owolabi, et al., 2012). In this review, an attempt is made to examine the properties of various non edible seed oil sources of biodiesel that are gaining increasing importance and their chances as future fuels.

Castor Seed oil

Castor *(Ricinus communis L.*) belongs to the *Euphorbiaceae* family, a diverse and economically important family of flowering plants. The plant has many common names such as castor plant, castor oil plant, castor bean plant, wonderboom, dhatura, eranda, Palma Christi. Locally the plant is known in Nigeria by such names as “Zurman” (Hausa), “Laraa” (Yoruba). “Ogilisi” (Igbo), “Kpamfini gulu” (Nupe), “Jongo” (Tiv), and “Era ogi” (Bini). The castor plant is considered by most authorities to be native of the Tropical Africa, and may have originated in Abyssinia, Ethiopia (Weiss, 1971, Kumar and Sharma, 2011). According to Sani and Sule (2007), the plant is a native of India with about 17 species that have been grouped into two: as shrubs and trees that produce large seeds or as annual herbs that produce smaller seeds. The castor bean plant consists of several branches, each terminated by a spike. The mature spike is 15 to 30 cm long and each spike bears 15 to 80 capsules. A capsule contains three seeds each, which, at maturity, split to release the seeds. The seeds of the castor plants that grow in northern states of Nigeria have been classified into seven distinct varieties according to their sizes and colours. However, the seeds are more commonly classified into three groups that include the large seeds (variety major), medium seeds (variety intermediate) and the small seeds (variety minor). The commonest variety that grows in the northern parts of Nigeria is the variety minor. The castor oil makes up 35% to 55% of the weight of the seeds and the oil contains 85% to 90% ricinoleic acid (Sani and Sule, 2007). Derivatives of ricinoleic acid find use in a variety of products including hydraulic fluids, paints, printing inks, cosmetics, pharmaceuticals, etc. (Andrew et al., 2005). The seeds, leaves and stems of the plant contain the glycoprotein ricin, which is poisonous to humans and animals.

The transesterification of castor oil under supercritical ethanol using a catalyst-free continuous process was investigated by Vieitez et al. (2011). The effect of water concentration on the reaction medium, reaction temperature, pressure, and substrates flow rate were studied. A maximum ester content was achieved when the reactor content of the product increased with the operation temperature, but after certain temperature level the converse effect was observed. This adverse effect was attributed to oil degradation. A favorable effect on ester content was observed when the water concentration was increased, unlike the effect of water on the conventional alkali-catalyzed process. They concluded that high biodiesel yields can be achieved for the conversion of castor oil to ethyl esters under supercritical ethanol processing.

The use of castor oil methyl ester as possible alternative fuel for diesel engines was investigated (Bello and Makanju, 2011). The oil was extracted in a Soxhlet extractor using normal hexane as solvent. To overcome the high kinematic viscosity of the neat oil, a high molar ratio of 6: 1 was used to produce the methyl ester. The viscosity of the ester was high and further reduced by blending with diesel fuel to reduce it to within the American Society for Testing and Materials (ASTM) D6751-02 limits for biodiesel. The biodiesel was characterised and tested in a single cylinder diesel engine. The results obtained gave properties, torque outputs and specific fuel consumption that are close to those of diesel fuel thus confirming that it can be used as alternative fuel for diesel engines.

Sousa, et al. (2010) evaluated the production of methyl esters from castor oil and methanol after neutralisation of castor oil with glycerol. The reaction was carried out under atmospheric pressure and ambient temperature in a batch reactor, employing potassium hydroxide as catalyst. Results showed high yield of castor oil into methyl esters after neutralization of castor oil with glycerol. The highest yield observed was 92.5% after 15 minutes of reaction. The best operating condition was obtained by applying an alcohol to oil molar ratio of 6.0 and 0.5% w/w of catalyst.

Fatty acid methyl esters (FAMEs) from castor oil have been synthesized by methanolysis catalyzed by Sodium methoxide and the optimal transesterification conditions found (Canoira et al., 2010). However, some properties of the castor FAME rendered it unsuitable in pure state for direct use as fuel in internal combustion engines. Thus, blends with reference diesel were prepared and their properties evaluated. Among these properties, the oxidative stability of the blends shows a negative anti synergistic effect, that is, all the blends have an induction period lower than the pure reference diesel and the pure castor FAME. On the contrary, the lubricity shows a positive synergistic effect, the wear scar of the blends being always lower than those of the pure components. The cold-filter plugging point of the blends shows also a singular effect, since the filterability remains identical to that of the reference diesel until around 50 volume % of castor FAME has been blended with it. The blends of castor FAME and reference diesel until approximately 40 volume % of castor FAME meet most of the specifications of the EN 590 standard

Jatropha curcas Seed oil

Jatropha curcas is a drought-resistant oil bearing multipurpose shrub/small tree which belongs to the family of *Euphorbiaceae*. It originated from Central America and was distributed by Portuguese seafarers via the Cape Verde Islands to countries in Africa and Asia. These days jatropha is widely grown in Mexico, China, north-east Thailand, India, Nepal, Brazil, Ghana, Mali, Foso, Zimbabwe, Nigeria, Malawi, Zambia and some other countries (Baroi et al., 2009). There are 175 species of jatropha around the world. Jatropha grows in arid and semi-arid climates and in a wide range of rainfall regimes, from 200 to 1500 mm per annum. It can survive in poor stony soils. The plant grows quickly forming a thick bushy fence in 6-9 months, up to a height of 4 m with thick branches in 2-3 years and the branches contain latex (Augustus et al., 2002). The life span of the Jatropha curcas plant is more than 50 years. Almost all parts of the plant have a medicinal value. The bark is rich in tannin and also yields a dark blue dye. The tender green leaves are fed to silkworms, for small scale silk production (Augustus et al., 2002). In many countries Jatropha is planted in the form of hedges to protect gardens and field crops from roaming animals. Since jatropha plants have lateral roots near the surface, they can be used to fix small earth dams which reduce the flow of run-off water. Its seeds resemble castor seeds in shape, but are smaller and brown (Augustus et al., 2002) and have an annual seed yield of 5 tonnes per hectre. According to them one of the estimations shows that the seeds contain 30-32% protein and 60-66% lipid. The oil content of the seeds varies from 30 to 60% depending on the variety, place and the method of oil extraction. The seed and /or the oil have been found to be toxic, so the oil cannot be used for cooking purposes and the cake remaining after extraction of the oil from the seed cannot be used as cattle feed or for any edible purpose. The cake contains about 6% N, 3% P, and 1% K. The oil has an excellent fuel property.

The lipid fraction of Jatropha oilseed were extracted and analysed for their chemical and physical properties such as acid value, percentage free fatty acids (% FFA), iodine value, peroxide value and saponification value as well as viscosity, and density (Akbar et al., 2009). According to them fatty acid and triacylglycerol (TAGs) composition of the extracted lipid was revealed using the gas chromatography (GC) and high pressure liquid chromatography (HPLC) method. Both oleic acid (44.7%) and linoleic acid (32.8%) were detected as the dominant fatty acids while palmitic acid and stearic acid were the saturated fatty acids found in the Jatropha oil. They concluded that the oil extracts exhibited good physicochemical properties and could be useful as biodiesel feedstock and industrial application.

The physic-chemical parameters like moisture content, oil content, specific gravity, density, viscosity, refractive index, iodine value, saponification value and acid value (%FFA) of Jatropha seed oil were determined. The extracted oil was then converted into biodiesel by transesterification process with methanol using different concentrations of alkali catalyst viz. 0.5%, 1.0%, and 1.5% NaOH. The result showed that 1% NaOH catalyst was found to be the most effective concentration producing 87% crude fatty acid methyl esters (FAME) and 10% crude glycerol (Shrestha et al., 2013).

Antony et al. (2011) produced biodiesel from jatropha oil and characterized its properties. The oil was first agitated with 4% hydrochloric acid (HCl) solution for 25 minutes and 0.82g of NaOH was added per 100 ml of oil to neutralize the free fatty acids to below 2%. This was followed by transesterification at the optimum condition of 6:1 methanol/oil and 0.92% NaOH catalyst at 60^{o}C for 1 hour. The properties of the jatropha oil and biodiesel produced were compared with that of fossil diesel. Results indicated that properties of jatropha oil and biodiesel are higher compared to that of fossil fuel in terms of flash point, fire point, pour point, cloud point, viscosity, specific gravity and refractive index. However, the calorific value is higher than that of jatropha oil and biodiesel

Neem Seed oil

The Neem is a tropical evergreen tree related to Mahogany. Native of east India and Burma, it grows in much of south east Asia (Munoz-Valenzuela et al., 2007). It has also been found to thrive in the semi tropics arid and semi arid climates in some countries including Nigeria where it is known as “Dogon Yaro” (Ayoola et al., 2014, Yakubu and Bello, 2015). The Neem does not require high fertile soils, has been grown in barren lands.It does not however support marshy or acid lands. The tree physiology requires temperatures that vary between 8^{o}C and 40^{o}C. The more hot and humid climate, the faster is the growth. The Neem tree has a very long life of up to two hundred years (Filho, 2005). Neem seeds contain 20-30 wt. % oil, and its kernel contains 40-50% brown oil (Pal et al., 2015). Neem oil has very high FFA content. Its oil has a rather strong odour that is said to combine the odours of peanut and garlic and is composed mainly of triglycerides and contains many triterpenoids which are responsible for the bitter taste and disagreeble odour (Usman et al., 2013). They reported the average acid composition of neem oil as follows: Linoleic acid (6-16%), oleic acid (25-54%), palmitic acid (16-33%) and stearic acid (9-24%) and gave some standard properties of neem oil as shown in Table 1

Table 1 : Some properties of Neem oil

Property	Literature value
Odour	Garlic
Specific gravity	0.908 – 0.934
Refractive index at 30^{o}C	1.4615 – 1.4705
pH	5.7 – 6.5
Iodine value	65 – 80
Acid value	40 mg KOH/g
Saponification value	175 – 205 mg KOH/g

(Usman et al, 2013)

In another study neem oil was extracted using food grade ethanol in an agitated pilot scale solvent extractor (Usman et al., 2014). The maximum percentage yield was 36.86% and was obtained when flat blade turbine impeller was operated at 84 rpm for 40 minutes contact time at 50^{o}C extraction temperature and particle size of 0.425 – 0.710mm. The Gas Chromatography and Mass Spectrometer results show the fatty acid composition of the extracted neem oil compares favourably with standard values. The composition of the neem oil suggests its application for industrial usage. The properties of the neem oil extracted such as specific gravity, pH, refractive index, iodine value acid value, and Saponification value compare favourably with standard values. Radha and Manikandan, (2011) reported that compared to conventional diesel fuel, engine exhaust emissions including smoke and CO were reduced, while NO_x was increased when fueled with neem biodiesel blends. They concluded that the ester of neem oil can be used as environment friendly alternative fuel for diesel engine creating a greener environment in the future.

Bhandare and Naik (2015) screened and evaluated thirty seed oils of neem in an experiment for their physico-chemical parameters for oil content, biodiesel yield, density, viscosity, iodine value, free fatty acid, flash point and fire point for the production of biodiesel. They found that the oil content varies from 25 to 45%. Higher oil content of neem indicates its suitatability as a non edible vegetable oil feedstock in oleochemical industries. According to them, soil conditions play a significant role in causing variations in oil yield. The base-catalysed transesterification was used as a process for the production of the biodiesel and yield was in the range of 60-85%. The density of neem oil was found to be higher than diesel. Higher density means more mass of fuel per unit volume for vegetable compared to diesel. The higher mass of fuel would give higher energy available for work output per unit volume. They further reported that viscosity of oil obtained was in the high range. Higher viscosity of biodiesel implies that biodiesel has a lubricating effect in engines which will be an added advantage to the users since it will reduce wear and tear in the engines. Free fatty acids(FFA), the major factor for determination of oil quality for biodiesel formation was found to be low and within internationally acceptable limit. The flash piont and fire point of neem biodiesel were also within ASTM Standards. Neem seed oil was found to have met the major specifications of biodiesel standards of USA, Germany and European Standard Organisation. A comparative study on the combustion characteristics of Neem oil for use as diesel substitute on a compression ignition engine was made (Lokeshwar et al., 2011). The Study revealed that on blending the Neem oil with diesel a remarkable improvement in their physical and chemical properties was observed. Cetane number came to be very close to pure diesel. Engine performance results indicated that engine ran at 20% blend of oil showed a closer performance to pure diesel.

A study carried out by Aransiola et al. (2012) investigated biodiesel production using crude neem oil having high acid value as feedstock. The effects of some operating variables were ascertained and its combustion performance was assessed in an internal combustion engine. Due to its high acid value, the neem oil was processed via two step acid–base transesterification process. The first step reduced the acid level to <2mgKOH/g while the second step involved direct conversion to fatty acid methyl ester using 1% NaOH as catalyst. The lowest viscosity value was used as a proxy

measure to determine the extent of the reaction. The results revealed the optimum conditions for biodiesel production to be ratio 1:6 of oil to methanol and 1.5 h reaction time. The viscosity at this condition was 5.53 cSt. The same procedure was repeated for $NaOCH_3$ catalyst concentrations of 0.5, 0.75, 1 and 1.25%. The lowest viscosity of 6.79 cSt was recorded at both 1 and 1.25% catalyst concentrations. The fuel properties of the biodiesel compared favorably with the recommendation by the American Standard Testing Method. The emissions of different blends showed that Neem biodiesel has lower emissions of CO and NO than petrol diesel but higher NO_X. They concluded that Neem oil as non- edible oil can be a good renewable raw material for biodiesel production.
A comparative study of the functional properties of Neem, Jathropha, Castor and Moringa seed oils as potential feedstocks for biodiesel production was undertaken by Zaku et al. (2012). The results showed that all the oils can be used as raw materials to obtain biodiesel fuel of high quality and could be suitable alternative to fossil fuel diesel.

Kumar and Sharma (2011) reported that crude Neem oil with high free fatty acids (FFA) of 21.6% was pretreated with an acid catalyst and the FFAs were reduced to less than 1% and the reaction optimized. This process gives yield of 89% Neem biodiesel which has comparable fuel properties with that of diesel and are within the limits prescribed by American Standard of biodiesel.No (2011) compared the perfomance and emission characteristics of neat neem oil and neem oil blends (25%) with diesel fuel and found that neem oil showed lower NOx emission when compared with diesel and neem oil blends. Neem oil blends with diesel showed slightly higher smoke intensities than diesel. Carbon monoxide and hydrocarbon emissions of neem oil blends were lower compared to their neat neem oil and mineral diesel. The brake thermal efficiency of neat neem oil and its blends were comparable to diesel fuel.

Kajale et al. (2014) produced biodiesel from neem seed oil and investigated its effect on engine performance and emissions. Biodiesel performance and testing was done in compression ignition engine. The conversion of biodiesels energy to work was equal to that from diesel fuel. The results also clearly indicate that the engine running with neem biodiesel and blends have higher NO_x emissions of up to 20%. However emissions of the CI engine running on neat biodiesel (B100) were reduced by up to 15%, 40% and 30% for CO, CO_2 and HC emissions respectively as compared to diesel fuel at various operating temperatures. They concluded that neem seed oil is good biodiesel feedstock.

Sathya and Manivannan (2013), performed a two- step transesterification process to convert the high FFA oils of Neem to its mono ester. Using 100mL of oil, the optimum pretreatment parameters were found to be 0.45 v/v methanol/oil ratio, 0.5% v/v H_2SO_4 catalyst, 50^oC and 45 minutes reaction time. The transesterification reaction was carried out with 0.3: 1 methanol to oil ratio, 1% KOH as alkali catalyst, 1 hour reaction time and 55^oC reaction temperature to produce the fatty acid methyl ester. The two step process gave maximum average yield of 90% with properties comparable to diesel fuel.

The optimisation of biodiesel production from Neem (*Azadiracta indica*) oil using a two step transesterification process and determination of the qualities of the neem biodiesel was investigated by Awolu and Layokun,(2013) with the view to establish its production viability potentials. The first step was carried out using 0.6 w/w methanol to oil ratio in the presence of 1% w/w H_2SO_4 as an acid catalyst in 1 hr at 50°C. The second step was base (NaOH) transesterification of the product of the first step using methanol/oil ratio of 1.5 to 7.5, catalyst amount (0.45% to 1.45% w/w), reaction time (45 to 65 minutes) and reaction temperature (45°C to 65°C). Optimised biodiesel yield was 89.69% at reaction time of 65 minutes, catalyst amount of 0.95% w/w, temperature of 55°C and methanol/oil molar ratio of 45: 1. The values of the physico chemical propertis are 0.05 moisture content, 0.9 specific gravity at 25°C, 5.5mm^2/s kinematic viscosity, 207mg KOH/g, 70.7 I_2/100g iodine value, 55.31 cetane number, 39.85MJ/kg calorific value, 4°C pour point, 8 °C cloud point and 110 °C fash point which all conformed with ASTM standards. They concluded that the production of high quality biodiesel from Neem oil using the two step transesterification is viable.

A study was conducted to investigate the performance of a stationary single cylinder diesel engine running on neem oil and neem biodiesel blended with diesel with varying proportion of 10%, 20%, and 30% by volume and also on diesel fuel alone by Heroor and Bharadwaj (2013). Results showed that at 200 bar injection pressure diesel had highest peak pressure followed by B30, B20 and B10 this trend remain same as the load increases. Among all blends cylinder pressure of B20 and B30 were almost same as diesel at all loads. At 220 injection pressure all blends of biodiesel has comparable value as diesel at 25% load. At 0% load B20 had least cylinder pressure. They concluded that filtered neem oil (biodiesel) can be a substitute of diesel because the properties like calorific value, density and viscosity are very much comparable with diesel.

A study of biodiesel properties of a hybrid of castor oil + neem oil and its performance with various blends was conducted. For diesel engine, the performance increased by 2-5 % and emission level was quiet lower than present diesel fuel. The hybrid has the potential to reduce total lifetime carbon dioxide emissions, as well as reduction in other pollutants (Sampatrao et al., 2014).

Thangaraj et al. (2013) prepared biodiesel from the crude non-edible oil from the seeds of the neem tree (*Azardirachta indica*) using a two-step reaction systems such as acid and alkaline esterification with short chain alcohol like methanol. The physical and chemical properties of synthesized biodiesel were then examined. Important fuel properties of Neem oil biodiesel such as kinematic viscosity at 40ºC (5.81 cSt), density at 15ºC (0.898 g/m^3), flash point (175ºC), pour point (8ºC), total sulfur content percent by mass (0.03), ash percent by mass (0.00), carbon residue percent by mass (0.08), copper strip corrosion for 3 hour at 100ºC (Not worse than No. 1), sediment percent by mass (0.00), water content percent by mass (0.00) compared well with other methyl esters. Neem oil methyl ester (NOME) has blended with conventional diesel at various proportions and its physical property of kinematic viscosity was measured at the temperature range up to 95ºC. The viscosity of B20 (20% NOME + 80 % ordinary diesel) blended with diesel has 3.81 cSt at 30ºC close to conventional diesel. A maximum yield of 85% biodiesel was achieved using 1:8 molar ratio of oil to methanol with 0.08% volume of acid catalyst and 1% of NaOH catalyst at 60ºC by two step reaction processes.

An environmentally benign process for the transesterification (methanolysis) of neem oil to fatty acid methyl esters (FAME) using Zn-Mg-Al hydrotalcites as solid base catalysts in a heterogeneous manner was carried out. The catalysts were characterised by X-ray diffraction (XRD), Fourier transform infra-red (FT-IR), TPD-CO_2, and the BET surface area analysis. The effects on biodiesel production of the methanol/oil molar ratio, reaction temperature, and catalysts amount were studied. Catalysts with Zn-Mg-Al molar ratio 3: 3: 1 exhibited maximum catalytic activity for transesterification of neem oil with methanol. The highest triglyceride conversion rate of 92.5% was achieved after 4 hours of reaction at 65^{o}C, with a 10: 1 molar ratio of methanol to Neem oil and 7.5g catalyst. The study revealed that the calcined nano hydrotalcite is an effective catalyst for the synthesis of biodiesel from Neem oil (Chelladurai and Rajamanickam, 2014).

Awolu (2015) conducted a research to evaluate the emission characteristics and engine performance of neem oil biodiesel using a single cylinder one-stroke 165 jet diesel engine. Automotive gas oil (AGO) was blended with Neem oil biodiesel (NOB).The blends were subjected to combustion in the single cylinder one-stroke jet diesel engine coupled with EGA4 palm top flue gas analyzer which was used in order to determine the effect of varying speed (750rpm and 900rpm) on the exhaust gases (CO and NO). Also, the engine power and specific fuel consumption were calculated in order to determine the efficiency of neem oil biodiesel in combustion engine. The combustion and the analyses were carried out, first by using a100% AGO, then100% NOB followed by other blends. The result showed that there were reduction in CO and NO emission while using neem oil biodiesel. The result also showed that neem biodiesel blends had engine power and specific fuel capacity similar to AGO. Neem oil biodiesel can be used with or without blends with AGO in diesel jet engines with lower emission characteristics and similar engine performance with that of AGO.

The life cycle assessment (LCA) with respect to, global warming potential, acidification potential and energy balance of a small scale biodiesel system using Neem oil as feedstock, in rural Karnataka (a southern state in India) was carried out by Lokesh, et al. (2015). The environmental impacts have been bench marked with the life cycle impacts of fossil diesel system and Jatropha. Global warming potential of neem biodiesel life cycle was found to be 1.2 times higher than fossil diesel system and 2.7 times higher than Jatropha biodiesel system. Acidification potential of neem system was found to be negligible. It is observed that one hectare of neem plantation is capable of sequestering the 1.35 tonnes of biogenic CO_2 released during the neem biodiesel life cycle, with additional sequestration potential of 8.65 tonnes CO_2 ha^{-1}. Net energy ratio of neem biodiesel life cycle has been found to be 26 times higher than fossil Diesel system and twelve times higher than Jatropha system. The life cycle study revealed that producing biodiesel from neem oil is ecologically sustainable.

Yellow Oleander Seed oil

The Yellow oleander (*Thevetia peruviana*) belongs to the family of plants called Apocynaceae. It is a small tree or shrub with yellow, bell- shaped flowers native to the mediterranean regions of southern Europe and south west Asia. The family includes diversities of species such as annual, perennial stems, succulent vines and shrubs and is well represented in parks and gardens, It is known as yellow oleander (nerium), gum bush, bush milk and exile tree in India, *keremuje*, *kerebuje*, *kanminko* in Yoruba, South- Western Nigeria and is used as edge shrub. *Thevetia peruviana* has a wide range of application not only in horticultural sector, but also in phamaceutical sectors among others (Ilori et al., 2013).

In Nigeria, it thrives in almost every part and it is grown in most parts of the country for horticultural purposes due to its beautiful flowering habit. It is a fast growing plant and takes one to three years to fruit. Transplants of oleander are easy from woody stem cuttings. The fruit of yellow oleander plant is trapezoidal in shape having two to four seeds in it. The seeds have high oil content (Oseni et al., 2014). Sahoo et al. (2009) reported that the oil yield is as high as 67% depending on geographical location. *Thevetia peruviana J.* plants produce more than 400-800 fruits yearly depending on rainfall and plant age.Figure 1 shows the Yellow Oleander plant.

Yarkasuwa et al. (2013) extracted oil from Yellow Oleander seeds with n- hexane in a soxhlet extractor and transesterified the oil with 50% potassium dioxide in ethanol and methanol respectively by weight of oil as catalyst. The biodiesel was tested for biodegrability using E. coli. The percentage yield of the fatty acid ethyl ester (FAEE) and fatty acid methyl ester(FAME) were 84.8% and 91.6% respectively. The biodegrability values of 81.4% and 86.4% were obtained for FAEE and FAME, respectively after a period of 28 days. Other fuel quality parameters determined are the cetane index of 47.19 (FAEE) and 59.97 (FAME), flash point of 198^{o}C (FAEE) and 175^{o}C (FAME), kinematic viscosity at 40^{o}C of 5.21 mm^{2}/s (FAEE) and 5.10 mm^{2}/s (FAME), pour point of 4^{o}C (FAEE) and -2^{o}C (FAME) and cloud point of 6^{o}C (FAEE) and 3^{o}C (FAME). They concluded that yellow oleander oil has a high potential for use in the production of environmentally friendly biodiesel. In another study crude yellow oleander oil was transesterified by Olatunji et al. (2011) using NaOH catalyst and methanol to produce biodiesel. The conversion was 94% at 55^{o}C with1:10 oil/methanol molar ratio for 1 wt% NaOH. The fuel properties especially viscosity, 4.82 cSt at 40^{o}C and flash point of 160^{o}C of the transesterified product compare well with accepted biodiesel standards.

Oseni et al. (2012) carried out a comparative evaluation of the effect of fatty acid profile on the thermal properties of ethyl esters of yellow oleander (*Thevetia peruviana*) oil and groundnut (*Arachis hypogiaea*) oil as biodiesel feedstock. Chemo- physical properties of the oils and their fatty acids profile were determined for the biodiesels produced. Results showed that the chemo-physical properties obtained for ethyl ester of yellow oleander oil such as flash point (48.67^{o}C), fire point (86.33^{o}C), cloud point (12.3^{o}C), pour point (2.33^{o}C) and free fatty acids (0.65%) were consistent with ASTM stipulated standard for fuel grade biodiesel. Yellow oleander feedstock has low free fatty acid content (<1%) which is close to the required standard for biodiesel production compared to groundnut oil with high FFA (9.93%).

A review of the properties of some seed oils (Yellow Oleander, Koroch, Terminalia and Nahar) was carried out by Basumatary (2013). It was found that the oil content and other fuel properties meet the properties prescribed in the biodiesel standards ASTM D6751 and EN 14214. The four species are considered highly promising feedstocks for biodiesel industries. The properties of the four species compared favourably to the specified fossil diesel particularly in terms of density, viscosity, cetane number and acid values. However the total sulphur in the biodiesels was higher than the 10-15 ppm maximum specified for fossil diesel.

A study was carried out by Adamu et al. (2015) to ascertain the potential of yellow oleander as an alternative to diesel fuel for an internal combustion engine while providing acceptable engine performance. A 3.5kg of seeds was obtained, dried, cleaned, milled and 1.9 liters of oil was extracted by hand press. The oil was transesterified with 4 solvents blended within 6 ratios and tested in a power point F165 single cylinder four stroke diesel engine. This was connected to aTD114 instrumentation under varying torque conditions for measuring engine performance. Engine parameters investigated includes among others are: Power developed and specific fuel consumption. Regression was analyzed based on torque fit line to examine the indices tested. The average exhaust emissions of carbons from diesel engine had effect on biodiesel blends and engine torque. Emission was found to decrease with the increase in proportion of biodiesel in the fuel blends, NOx increases with increase in biodiesel while SO_2 decreased with increase in the ratio of biodiesel. Based on the studies on physicochemical properties of yellow oleander, it was discovered that oil obtained from yellow oleander is eco-friendly and can be alternatives to diesel fuel that has higher effect of emissions which increase global warming.

Nwakaire and Durugu(2013) performed experiments for the determination of physio-chemical properties of Oleander seed oil for biodiesel production. The mean major, minor and intermediate diameters of twenty Nerium Oleander seeds were 3.53 cm, 1.85 cm and 1.98 cm respectively. The volume, density and sphericity of the seeds were reported to as 7.70 cm^3, 0.49 g/cm^3 and 0.69 respectively. The seed oil exhibited good chemical properties for biodiesel production with a viscosity of 46.58mpa/s at 30^oC, Free Fatty Acid (FFA) of 3.92%, cloud point of 2^oC and a flash point above 200^oC. The ash content, moisture content, melting point, density at 15^oC, cetane number and the heat of combustion were reported as 1.44%, 0.33%, 8^oC, 0.898 g/cm^3, 63.55 and 125.37 kJ/L, respectively. The cetane index of Nerium Oleander seed oil had high cetane index when compared to the ASTM D6751 standard for diesel fuels. It was concluded that the Oleander seed is an alternative feedstock for biodiesel production.

Ana and Udofia (2015) evaluated the biodiesel yielding potential of *Thevetia peruviana* seeds. Oil was extracted from the seeds using Soxhlet and Cold-solvent extraction methods. Hexane-only (H-only) was used in the Soxhlet while Hexane/Ether (H/E) mixture and H-only were respectively used in the Cold extraction. The oil was processed using Methanol/Ethanol (M/E) mixture and Methanol-only (Monly) respectively to biodiesel via transesterification with sodium hydroxide as catalyst. The oil and biodiesel physicochemical parameters such as density, viscosity at 40^oC, Saponification value, Flash Point (FP) and Acid Value (AV) were determined using the American Standard for Testing and Material (ASTM D6751) methods. The oil yields from Soxhlet, H/E and H-only extractions were: 62.3%, 51.9% and 45.8% respectively. The biodiesel yield in the M/E and M-only transesterifications were: 78.4% and 85.20% respectively. The density at 40^oC, viscosity, and saponification value of the oil were: 0.868g/cm^3, 21.50mm^2/s and 120mgKOH/g respectively. The density at 40^oC, viscosity, FP and AV of the biodiesel were: 0.760g/cm^3,

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4.70mm^2/s, 130^{o}C and 0.441mgKOH/g respectively. The seeds of *Thevetia peruviana* are viable sources for biodiesel production, and quality parameters of the biodiesel met the American Standard for Testing and Materials limits (ASTM D6751).

Raj and Manokar, (2016) reported thata single-cylinder compression ignition engine was operated successfully on neat Yellow Oleander(*Thevetia Peruvina)* Seed Oil (TPSO) and TPSO with Diethyl Ether (DEE) at 3.5 kW load and the various performance, combustion and emission characteristics such as thermal efficiency, and brake specific fuel consumption, volumetric efficiency were measured. According to themmixing of 5%DEE with TPSO increases the brake thermal efficiency. The brake thermal efficiency is 34.9% with5% of DEE, with neat TPSO it is 28.2% and all biofuels had highest value of combustion duration compared to that of diesel. They concluded that DEE mixed TPSO can be used as a fuel in diesel engines because combustion characteristics on the engine was significantly improved.

Oil was extracted from dried yellow oleander seeds using Soxhlet extractor which was used to produce biodiesel using different types of catalyst (KOH and NaOH).The properties of biodiesel were checked. Results showed that biodiesel quality parameters such as yield(85% and 90%), flash point (171 ^{o}C and 176 ^{o}C), fire point (195^{o}C and 198^{o}C), viscosity (4.9991 and 5.21 mm^2/s) for the biodiesel from yellow oleander seed oil produced by using KOH and NaOH respectively. They concluded that the seed oil of yellow oleander is a viable feedstock for good quality fuel and substitute for conventional fuel **(**Rashmi et al., 2015). Thevetia peruviana biodiesel was emulsified with water in the ratios of 5, 10, 15 and 20% to investigate the engine performance and emission characteristics. Emulsified fuels showed an improvement in brake thermal efficiency accompanied by the drastic reduction in NO_x. From the detailed study it was found that 15% water emulsified fuel showed the best performance and less emission than the other combinations (Kannan and Gounder, 2011).

CONCLUSION

The following conclusions can be reached from the review.
Castor oil has very high kinematic viscosity which may be reduced by using high molar ratio during transesterification although it still needs to be blended with diesel fuel to bring it to the limits for biodiesel. The torque and power output characteristics are comparable to that for diesel fuel but the load carrying capacity is about 20% higher as a result of its oxygen content which allowed for more complete combustion and operates to a lower speed.

The properties of the biodiesel produced from crude neem, yellow oleander and jatropha seed oils compared favourably with the values prescribed by American Standards of Testing and Materials (ASTM).The results obtained in this review would be relevant in the development of biodiesel production from Neem oil especially in countries where this feedstock is abundant. These properties have a lot of potentials and are useful for design of processing and handling machineries. The blends of the seed oil with diesel showed performance characteristics close to fossil diesel, therefore the blends can be used in CI engines for meeting energy requirement in various agricultural operations such as irrigation, threshing and other fields of endeavors High quality biodiesel can therefore be produced from non edible seed oils without affecting the oil needs in our foods.

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