



Preliminary Studies on Biofuel Potentials of Silk (*Ceiba pentandra*) Castor (*Ricinus communis*) and Cotton (*Gossypium hirsutum*).

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Abstract

The aim of the study is to investigate the suitability of *Ceiba Pentandra* (Silk cotton), *Ricinus Communis* (Castor) and *Gossypium hirsutum* (cotton) for the uses as biofuel feed stock. The seed oil in each of the samples was extracted using soxhlet extractor, analyzed for their physicochemical properties. From the analysis, it was found that the percentage oil yield of 51.00%, 43.02% and 42.50% were obtained for Castor, Cotton and Silk respectively. Other fuel properties test indicates that the oils have saponification value (209.60; 232.30; 198.660mgKOH/g). Iodine value (43.10, 51.25 and 35.02 mg/g). Ester value (188.79, 195.86 and 219.60) for silk castor and cotton seed oils respectively. All the evaluated properties of the seed oils produce were within the limits prescribed by AOAC and ASTM Standard.

Keywords: Biofuel; Oil Seeds; physicochemical properties; Cotton; Castor.

1.0 INTRODUCTION

Energy is very important and all aspects of human activities are linked to it. The operations of our technological society depend upon the production and use of large amount of energy. Nations are fast developing industrially and in social status, as a result of which more individuals own cars, trucks, heavy duty machines, power generating plants and other forms of mechanical devices which operate using one

form of fuel or the other. There is therefore an exponential increase in the use and demand for fuel in terms of power generation, transportation and mechanized agriculture. The sources of fuel to run these engines have so far been extracted from our stock of fossil fuel such as crude oil and to a lesser extent coal and natural gas, all of which are finite and environmentally intolerable (OPEC, 1994).

Fast depletion of fossil fuels resulting in unpredictable increase of crude oil prices and growing worldwide concern for environmental degradation have necessitated that alternative energy sources be expeditiously identified to replace traditional fossil fuels (Gerhard, 2009). A very key feature of alternative sources of fuel energy is that they can be domesticated to meet the needs for social and economic progress, especially in rural communities where fossil fuels may be expensive or difficult to obtain (Nwafor and Rice, 2000).

1.1 Environmental Issues

In view of environmental consideration, Barnwal and Sharma (2005), considered biofuel as being carbon neutral, because all the carbon (iv) oxide (CO₂) released during combustion can be sequestered from the atmosphere for the growth of vegetable oil crops. Studies have shown that combustion of 1 kg of diesel fuel leads to the emission of about 2.6 kg of CO₂ as against 1 kg of CO₂ per kg of biodiesel. So the use of biodiesel may directly displace this amount of CO₂ when used in engines (Rosenblum, 2000). Relative to conventional diesel fuel, its combustion products have reduced levels of particulates, CO, sulphur oxides, hydrocarbons, soot and under some conditions, Nitrogen oxides (Devenesan *et al.*, 2007). Biodiesel is essentially free from sulphur and has decreased emission of

2.0 MATERIALS AND METHODS

2.1 Sample Collection and Treatment

The samples were obtained from different location in Northern Nigeria. The samples of Silk cotton seeds were obtained from Malumfashi in Katsina State, castor seed from National Research Institute for Chemical Technology (NARICT) Zaria while cotton seeds were obtained from Bangi in Niger State. The seeds collected were separately cleaned by removing foreign materials such as ticks, stains, leaves, other seeds, sand and dirt. The dried seeds were

polycyclic aromatic hydrocarbon. Nitrous oxides (NO_x) emissions are reported to be in the range of 10% and greater when compared to diesel depending on engine combustion characteristics (Fiaz and Sturm, 2000).

Estimates show that green house gases (GHG) emission, including CO₂, CH₄ and NO_x are reduced by 41%, if the biodiesel is produced from crops harvested from field that were already in production. The analysis of exhaust gases suggests that biodiesel is an environmentally safer fuel. Test conducted by the United State Environmental Protection Agency (USEPA) have shown that the use of biodiesel almost completely eliminates life cycle of CO₂ emissions (Bapjai and Tyagi, 2006). This benefit occurs because biodiesel contain 11 % (w/v) oxygen (NREL, 2004). Thus, introduction of a renewable clean-burning alternative fuel is considered the best option available now (Kumar and Sharma, 2005). There are number of reasons for using bio-fuels as alternative fuel. These include expected growth of prices of fossil fuels in the near future and gradual depletion of crude oil sources in the next 100- 150 years (Bari *et al.*, 2002).

It was therefore the aim of the present study to investigate the suitability of *Ceiba Pentandra* (Silk seed oil), *Ricinus Communis* (Castor seed oil) and *Gossypium hirsutum* (Cotton seed oil) as biofuel feed stock.

then mechanically dehauled to remove the seed coat. The dehauled seeds were milled, packed separately and stored in polyethene bags prior to the commencement of analysis.

2.2 Extraction of Oil

Fifty gram (50g) of each powdered sample was placed in a thimble covered with cotton wool and inserted into a Soxhlet extraction chamber. The whole assembly was placed in a heating mantle; the extraction of the samples was carried out for six hours on a 500cm³ capacity Soxhlet extractor using n-hexane as the solvent. The oil was then

distilled in a reflux condenser to remove the solvent and obtain oil of high purity (Swehla, 1996). The oils were then placed in brown bottles and stored in a refrigerator for analysis. The percentage oil yield of each sample was determined using equation 1.

$$\% \text{ oil yield} = \frac{\text{mass of oil extracted}}{\text{mass of sample}} \times 100 \dots \dots \dots (1)$$

2.3 Physicochemical Analysis of the Oil

The acid value, free fatty acids, saponification value, iodine value and peroxide value were determined using standard method in (A.O.A.C, 1990)

2.3.1 Acid Value

The oil sample (2g) was weighed into a conical flask (250 cm³) and propan-2-ol (50 cm³) was added to ensure complete dissolution of Phenolphthalein indicator (3 drops) were added and mixed thoroughly. The mixture was titrated with KOH (0.1M) to faint pink colour end point (AOAC, 1990). The acid value was calculated using equation 2.

$$\text{Acid value} = \frac{56.1 \times \text{TV} \times 0.1 \text{MKOH}}{2 \text{g of the oil}} \dots \dots \dots (2)$$

Where TV=Titre value, 56.1= Molar mass of KOH

2.3.2 Determination of Free Fatty Acid (FFA)

The procedure employed for the determination of Acid Value applies to free fatty acids. The free fatty acid was calculated using equation 3

$$\text{FFA} = \frac{28.2 \times \text{TV} \times 0.1 \text{MKOH}}{2 \text{g sample Oil}} \dots \dots (3)$$

In other words, Free Fatty Acid is half the Acid Value (AOAC, 1998).

$$\text{FFA} = \frac{\text{Acid value}}{2} \dots \dots \dots (4)$$

2.3.3 Determination of Saponification Value

The oil (2.5 g) was weighed into 250cm³ conical flask and ethanolic KOH (25 cm³, 0.5M) was added. The mixture was heated to saponify the oil for 30 minutes. Another ethanolic KOH (25 cm³, 0.5M) was measured into conical flask (250 cm³) for blank titration without oil and was also heated for 30 minutes. The two flasks were allowed to cool and then titrated against HCl (0.5M) solution using phenolphthalein (1cm³) as indicator (Verma, 2001). The saponification value was calculated using equation 5.

$$\text{saponification value} = \frac{56.1 \times (\text{B}-\text{S}) \times 0.5 \text{MKOH}}{2.5 \text{g of oil}} \dots \dots \dots (5)$$

Where; B is the titre value of acid required in blank and S is the titre value of acid required in complete saponification of the oil.

2.3.4 Determination of Iodine Value

The oil (0.25g) was weighed into a conical flask (250 cm³), carbon tetrachloride (10 cm³) was added to dissolve the oil by swirling. Wijs solution (20 cm³) was also added, stoppered and stirred. The mixture was allowed to stand in the dark for 40 minutes. Potassium iodide solution (15 cm³, 10%) was then added to the mixture with water (100 cm³) also added. The mixture was swirled and titrated against solution of sodium thiosulphate (0.1M) with vigorous shaking at intervals until the yellow colour completely disappeared. Then 1cm³ of starch indicator was added and titration continued to a colourless end point. A blank titration was also carried out without oil sample. Iodine value was calculated using equation 6

$$\text{Iodine value} = \frac{(\text{B}-\text{S}) \times \text{N} (\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}) \times 12.69}{\text{Weight of the sample}} \dots \dots \dots (6)$$

Where; B= Titre value for blank, S=Titre value for the sample, N=Normality of Na₂S₂O₃.5H₂O (sodium thiosulphate solution, 12.69 = Concentration conversion coefficient (AOAC, 1990).

2.3.5 Determination of Peroxide Value (Wheeler method)

The oil (5 g) was weighed into different conical flasks (250 cm³) and 25 cm³ of solvent mixture (acetic acid-chloroform (3:2) was added and the content of the flask shaken for one minute before the addition of 35cm³ of distilled water. The mixture was titrated with a sodium thiosulphate solution (0.1M) using starch indicator. A blank determination was carried out without the sample.

$$\text{Peroxide value} = \frac{1000T(V_1 - V_2)}{W} \dots \dots \dots (7)$$

Where W = mass (in g) of oil, V₁ = Volume (in cm³) of sodium thiosulphate solution used

V₂ = Volume (in cm³) of sodium thiosulphate solution used in Blank

T=Titre of of sodium thiosulphate solution (Mol/dm³)

The ash content was determined using Muffle furnace, moisture content by air oven method and Refractive index using refractometer.

3.0 RESULTS AND DISCUSSION

Table 1: Physicochemical Analysis of the Extracted Seed Oils.

Parameters	Silk seed	Castor seed	Cottonseed
Ash content (%)	6.08±0.03	3.89±0.06	4.91±0.03
Moisture content (%)	2.66±0.12	3.43±0.08	2.91±0.01
Yield (%)	42.50±0.14	51.0±0.06	43.02±0.13
Acid value (mgKOH/g)	9.81±0.23	13.74±0.12	11.30±0.21
FFA (mg KOH/g)	4.91±0.12	6.87±0.06	5.6±0.11
Saponification value(mgKOH/g)	198.61±0.13	209.60±0.05	232.30±0.02
Iodine value (meq/g)	43.10±0.04	51.25±0.14	35.02±0.01
Peroxide value (meq/g)	45.01±0.06	13.03±0.04	71.04±0.04
Ester value	188.79±0.06	195.86±0.05	219.6±0.02
Refractive index (25 ⁰ C)	1.468±0.11	1.476±0.03	1.470±0.05

The percentage oil yield in Table 1 range from 42.5±0.14 to 51±0.06%, with silk

cotton having the least value and castor seed is having the highest. The yield obtained, fall

within the range of 30-55% as reported by Akpan *et al.*, (2006). These results indicate that all the sample seed contain appreciable quantity of oil that is enough to be extracted for commercial production of biodiesel. The feedstock can sustain large chemical industries not only involved in biodiesel production, but also for the production of detergent, surfactants, soap and nitrogenous derivative (Azam *et al.*, 2005).

The acid values of silk, castor and cotton seed oils range from 9.81 ± 0.22 to $13.74 \pm 0.12\%$ with Castor seed oil ($13.74 \pm 0.12\%$) gave the highest, followed by cotton seed oils $11.30 \pm 0.12\%$ and lastly silk oil (9.81 ± 0.22), respectively (Table 1). The values recorded for castor are higher than that of castor oil 12.48 mgKOH/g but less than that obtained for cotton oil 12.34 as reported for by Ndana *et al.*, (2011). High acid values as well as free fatty acids have adverse effect on transesterification of oils, especially non-edible oils. Presence of having high free fatty acid in biodiesel can cause system deposit and act as solvent resulting in the deterioration of rubber component of the fuel system (Weiksner *et al.*, 2006)

The moisture content obtained for silk, castor and cotton seed oil are shown in Table 1 as 2.66 ± 0.12 , 3.43 ± 0.08 and $2.91 \pm 0.01\%$ respectively. The values are lower than the 8.0%, 8.6% and 10% reported for castor, rubber seed and shear butter oil by (Asuquo *et al.*, 2010) and also compared to 7.3% chicken pea, 9.4 % cowpea and as reported by (Iqbal *et al.*, 2006). These extracts serve as feed stock for methyl ester production and the moisture content serve as index of storage quality of the seed.

Ash content for silk, castor and cotton are 6.08 ± 0.03 , 4.91 ± 0.03 and $3.83 \pm 0.06\%$ respectively. This is an indication of the presence of some mineral elements in the seeds which could be of economic importance. Generally the ash content were found to be higher than the reported value for calabash 3.4% by (Osagie and Eka, 1998) and lower than 13.8% for cotton reported by (Wawata, 1998).

The saponification values determine the quantity of potassium hydroxide (mg) needed to neutralized the acid and saponify the ester contained in 1g of the lipid (Roger and Steven, 2010). The saponification value for silk cotton, castor and cotton seed oil are (198.6 ± 0.13 , 209 ± 0.05 and 232 ± 0.02 mgKOH/g) respectively. These values are similar to those of seed oil of soybean, peanut and sunflower whose average saponification value range from 175 to 250 (O'Brien, 2004). The high saponification value shows that the oils contain normal triglyceride and are very useful in the production of soap and shampoo (Akbar *et al.*, 2009)

Iodine value is a measure of unsaturated fats and oils; higher iodine value shows high unsaturation (Knothe, 2005). The iodine values for the silk, castor and cotton seed oils are (43.10 ± 0.04 , 51.25 ± 0.14 and 35.02 ± 0.01 (meq/g) respectively. These values are lower than the range reported in sun flower oil (110-143), castor (83.75) and soybean (120-143) reported by Asuquo *et al.*, (2010).

The refractive index for silk, castor and cotton seeds oil in Table 1 are 1.458 ± 0.11 , 1.476 ± 0.03 and 1.470 ± 0.05 respectively. The Values obtained are consistent with that of soya bean oil (1.505°C). The refractive index of oils increases with increase in unsaturation of its component fatty acids (Hassan and Sani, 2006)

Peroxide values for the oils vary significantly indicating 71.04 ± 0.04 for cotton seed followed by 45.01 ± 0.06 for silk oil and 13.03 ± 0.04 for Castor oil being the least value. The low level of peroxide value is a proof of oxidative stabilities of the oil (Gunstone, 2004). Hence, the oil could be a good substrate for biodiesel production.

Ester value represents the number of milligram of potassium hydroxide required to saponify the ester present in 1g of the oil. It is obtained as the difference between the saponification value and acid value. The ester values for the silk, castor and cotton seed oil shown in table 1 are 188.79 ± 0.06 , 195.86 ± 0.05 and 219.60 ± 0.02 . The values

obtained are in agreement with those reported for castor (174.09), rubber (191.93) and Shea butter oils (183.4) Asuquo *et al.*, (2010)

4.0 CONCLUSIONS

Results of analysis on the potentials of castor, silk and cotton seeds for biofuels production reveals a yield of 51.05%, 43.02% and 42.5% for castor, cotton and silk seed oil

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