

CONVERSION OF JATROPHA CURCAS OIL TO BIODIESEL USING POTASH FROM COCOA POD HUSK (CPH) AND PALM KERNEL FROND (PKF) AS CATALYST

^{1*} O. M., Ameen, ¹ F. A., Adekola, ¹ G. B., Adebayo, ² O. F., Adekola, ³ M. A., Belewu and
¹ S. G., Rahman

¹Chemistry Department, University of Ilorin, Ilorin.

²Department of Agronomy, University of Ilorin, Ilorin.

³Department of Animal Production, University of Ilorin, Ilorin.

*Corresponding author e-mail Address: aommohd@yahoo.com; moameen@unilorin.edu.ng

Tel: +2348035019199

ABSTRACT

Caustic potash extracted from the ashed samples of cocoa pod husk (*Theobroma cacao*), and palm kernel fronds (*Elaeis guineensis*) was used to catalyse the conversion of *Jatropha curcas* oil to biodiesel. The physicochemical parameters and fatty acid components of the prepared biodiesel were comparable to those of the biodiesel prepared with commercial KOH. This work, thus established the fact that it is possible to use erstwhile wasteful plant products for useful purposes.

Keywords: cocoa pod; palm kernel frond; potash; biodiesel; fatty acid

INTRODUCTION

Since the last decade of the last century, biodiesel or methyl esters have become more attractive because of its environmental benefits and the fact that it is made from renewable resources. The biodiesel is a suitable substitute to fossil fuel whose reserve is exhaustible. Biodiesel is also an environmental friendly fuel because of its properties such as "clean burning" and "non-toxic" fuel, the biodiesel technology and market is highly prospective. It is manufactured from plant oils (soybean oil, cottonseed oil, canola oil, *Jatropha* seed oil), recycled cooking greases or oils, or animal fats (beef tallow, pork lard).

Biodiesel is produced by using base catalyzed transesterification process, as it is the simple process and requiring only low temperature. The transesterification process is the reaction of a triglyceride (fat or oil) with an alcohol to form esters and glycerol. The alcohol reacts with the fatty acids to form monoalkyl ester or biodiesel and crude glycerol (Peterson *et al.*, 1991). In biodiesel production process the main reaction is the transesterification of vegetable oil (Shay,

(1985). The important factor that affects the transesterification reaction is the amount of methanol and sodium or potassium hydroxide, reaction temperature and reaction time (Demirbas, 2003).

Cocoa (*Theobroma cacao*) is a vital export crop for many countries, particularly in South-East Asia and West Africa. The crop was introduced into West Africa, Nigeria inclusive through Fernando Po from Central America where it was native. Nigeria became a major producer and exporter of cocoa (Adedokun *et al.*, 2008). There are three main varieties of cocoa commonly grown in Nigeria, namely *Amezonia*, 'Foresteros' *Amelonado* and the hybrid of the two *Trinitarios*. Cocoa merits much economic significance in the producing countries the world over. Cocoa husks can be hydrolysed to produce fermentable sugar. Cocoa seed cake and the cocoa pod husk are used as part of feed ingredients for poultry, pig, sheep, goat, cattle, rabbits and fish after removing the theobramine (Adeyanju *et al.*, 1975; Smith and Adegbola, 1982; Ayinde *et al.*, 2010). The shell is a good source of potassium and can be used in the production of potassium fertilizer, local soap, biogas and particle boards (Simpson *et al.*, 1985; Moyin Jesu and Aiyemsoye, 2002; Ayeni *et al.*, 2009; Dongo *et al.*, 2009; Ayeni, 2010a; Ayeni, 2010b; Ogunlade *et al.*, 2010).

Despite the dwindling production of cocoa in Nigeria, the crop still contributes to the nation's economic development (Nkang *et al.*, 2009) in terms of foreign exchange earnings, employment generation, and source raw of materials for local industries. No single agricultural export commodity has earned more than cocoa. With respect to employment, the cocoa sub-sector still offers quite a sizeable number of people employments both directly and indirectly. In addition, cocoa is an important source of raw materials, as well as source of revenue to Governments of cocoa producing states (Ademosun, 1993).

Cocoa-pod is a by-product of the cocoa processing, after the beans have been extracted from it by the harvesting industry. It forms about 80% of the cocoa fruit and it is essentially a waste product except for the negligible amount used in the manufacture of local soap (Ayeni *et al.*, 2008). About 800,000 tonnes of cocoa pod husks generated annually in Nigeria are often wasted (Ayeni *et al.*, 2008) and it is known to harbour fungus causing black pod disease in cocoa. Thus, its use as organic manure may directly or indirectly transmit black pod disease to other plants, hence, cocoa pod are burnt (Ayeni, 2010b). However, Ayeni *et al.*, (2008), found that cocoa pod ash contained plant nutrients such as N, P, K Ca, Mg and micronutrients and is good for tomato production (Odedina *et al.*, 2003).

Oil palm (*Elaeis guineensis*) has been described as one of the most versatile oilseed crop grown in the tropical world. It is one of the economically important widely grown crops in the tropics especially in Nigeria. Oil palm locally called "Nkwu" (Igbo) and "Ope" (Yoruba) in Nigeria is native to West African humid tropics and extends towards the east across the Congo basin and rain forest belt of central Africa. It is the most important source of vegetable oil in tropical West Africa and it gives a higher yield of oil per unit area than any other crop (Soyebo *et al.*, 2005). The often referral of oil palm as a crop of multiple value underscores its economic importance. All its essential components namely, the fronds, the leaves, the trunk and the roots

are used for several purposes ranging from palm oil, palm kernel oil, palm wine, broom, and palm kernel cake. Besides palm oil and palm kernel oil, the oil palm industry also generates a number of by – products most of which have well established uses. Palm kernel cake, for instance, is an established animal feed; the fibre and shells are burnt as fuel in boilers to raise steam and the residual boiler ash is used for surfacing roads; oil palm bunch ash is a valuable potash fertiliser whilst the pruned fronds and, to a lesser extent, the trunks and stumps, are recycled in the field as organic manure (Akangbe *et al.*, 2011). In addition to these by-products potash has been reported to be produced from its wastes. For instance, Edoga (2009) reported the extraction of potash from Palm kernel bunches.

The present study aimed at investigating the suitability of potash obtained from cocoa pod husk (CPH) and palm kernel frond (PKF) as an alternative catalyst for the conversion of *Jatropha curcas* oil to biodiesel.

MATERIALS AND METHOD

Preparation of sample

The cocoa pod husks (CPH), and palm kernel fronds (PKF) used in this work were obtained from a farm in Ijumu village, Kogi State, Nigeria. The CPH and PKF were washed and sun dried for 6 days. The dried samples were blended to increase the surface area and ashed in a muffle furnace at 600 °C for 6 hours. The ashed samples were grinded and smoothened.

Determination of potash concentration

Ashes of CPH (20 g) and PKF (20 g) were separately weighed into a bottle, a litre of distilled water was added to the bottle containing the ashes respectively, and the mixtures were left for 5 days. It was then filtered by suction and the resulting solution titrated against 0.1 M HCl solution using methyl orange as indicator (Babayemi *et al* 2010).

Conversion of the *Jatropha curcas* crude oil to biodiesel

In this study, the *Jatropha curcas* oil was converted to biodiesel by the modified method of Ugheoke, *et al.* (2007).

Physical and chemical analyses

Specific gravity

This was determined using specific gravity bottle.

Acid, Iodine and Saponification Values Determinations

The acid, iodine and saponification values were determined using the method of BPC (1988).

Viscosity Determination

The viscosity was determined using Brookfield Digital viscometer (Model DV-1-DVTD) Brookfield Engineering Laboratory USA.

Free Fatty Acid and Peroxide Value Determination

Free fatty acid and peroxide values were determined using titration method A.O.A.C., (1990).

Flash point Determination

The flash point was determined using Pensky-Martens apparatus.

Determination of Fatty Acid Composition of the Biodiesel using Gas Chromatography

Fatty acid composition of the biodiesel was determined using GC was equipped with flame ionization detector and capillary column HP INNOWax (30 m × 0.25 mm × 0.25 µm). About 0.1 ml of the biodiesel was injected into the GC. The detector temperature was programmed at 320 °C with flow rate of 0.8 ml/min for 60 minutes. The injector temperature was set at 250 °C. Nitrogen was used as the carrier gas. The identification of the peaks was achieved by retention times by means of comparing them with authentic standards analyzed under the same conditions.

RESULTS AND DISCUSSION

Caustic potash contents of cocoa pod husks and palm kernel fronds are presented in Table 1. It was observed that the amount of KOH obtained from the cocoa pod husks is greater than that from palm kernel frond. It has been reported that cocoa pod husks is a good source of potassium boards, and this result agreed with earlier work that cocoa pod husks is richer than palm kernel fronds in their potash content (Simpson *et al.*, 1985; Moyin Jesu and Atoyosoye 2002; Ayeni *et al.*, 2009; Dongo *et al.*, 2009; Ayeni, 2010a; Ayeni, 2010b; Ogunlade *et al.*, 2010).

Table 1: Extracted KOH (%) from cocoa pod husks and palm kernel fronds.

	Cocoa Pod Husk	Palm Kernel Frond
Initial weight (g)	197.56	254.57
Ash yield	52.54	61.80
% potash	28.0	24.3

The extracted potash was subsequently used to prepare biodiesel from *J. curcas* oil to determine its effectiveness. The prepared biodiesel was subjected to physicochemical analysis and the result of the physicochemical analysis compared with those of biodiesel of *J. curcas* prepared using commercial potassium hydroxide. The result is presented in Table 2.

Table 2: Comparison of physicochemical parameters of biodiesel prepared using potash from CPH and PKF and that of commercial KOH

Parameters	CPH Biodiesel	PKF Biodiesel	Commercial KOH biodiesel
% Yield	83.33	64.0	80 ^a
Moisture content (%)	0.6	0.2	nd
Specific gravity	0.78	0.79	0.88 ^a
Density (g/ml)	0.86	0.87	0.87 ^a
Acid value	8.72	2.97	18.76 ^a
Iodine value	8.76	4.78	37.36 ^a
Saponification value	209.67	210.3	240.53 ^a
Viscosity (mm ² s ⁻¹)	3.11	2.41	9.60 ^a
Refractive index	1.436	1.471	nd
Flash point	210 °C	210 °C	200 °C ^a
pH	6.61	6.40	5.12 ^a

a – Belewu *et al* (2010)

The biodiesels were obtained in the yield of 83.3 and 64.0 for CPH and KPF potash respectively Table 2, these values are comparable to the result obtained for the biodiesel prepared using commercial KOH, Belewu *et al.*, (2010) which gave a yield of 80%, though the value of 64.0 % obtained for PKF potash is a little bit lower. Similarly, the specific gravity, density and flash point of the prepared biodiesel compared favourably with those of biodiesel prepared using commercial KOH, Table 2. However, there is mark difference in the values obtained for the iodine value, saponification value and viscosity. While the iodine value of the biodiesel prepared using commercial KOH is higher than those of the potash, the saponification value recorded a lower value, Table 2.

Fatty acid composition determination was also carried out to compare the characteristic of the diesels prepared (Table 3).

Table 3: comparison of the fatty acid composition of the biodiesels with *J. curcas* oil

Fatty acid	CPH Biodiesel	PKF Biodiesel	<i>J. curcas</i> oil ^d
Oleic acid 18:1	52.81	56.77	44.70
Linoleic acid 18:2	19.74	21.01	32.80
Palmitic acid 16:0	24.47	19.05	14.20
Stearic 18:0	0.48	0.68	7.00
Palmitoleic 16:1	-	-	0.70
Linolenic 18:3	0.37	0.46	0.20
Arachidic 20:0	1.95	1.81	0.20
Margaric 17:0	-	-	0.10
Myristic 14:0	-	-	0.10
Erucic 22:1	0.18	0.22	-
Saturated	26.90	21.54	21.60
Monounsaturated	52.99	56.99	45.40
Polyunsaturated	20.11	21.47	33.00

^d = (Emil *et al* 2009)

The properties of the triglyceride and the biodiesel fuel are determined by the amounts of each fatty acid that are present in the molecules. Chain length and number of double bonds determine the physical characteristics of both fatty acids and triglycerides. Fatty acid composition of the biodiesels presented in Table 3 was compared with those reported by Emil *et al.*, (2009) *J. curcas* oil. There are three main types of fatty acids that can be present in a triglyceride which are saturated (Cn: 0), monounsaturated (Cn: 1) and polyunsaturated with two or three double bonds (Cn: 2, 3) (Gunstone, 1994). Various vegetable oil is a potential feedstock for the production of a fatty acid methyl ester or biodiesel but the quality of the fuel will be affected by the oil composition. Ideally the vegetable oil should have low saturation and low polyunsaturation i.e be high in monounsaturated fatty acid (Gunstone, 1994). The predominant fatty acids in the biodiesels consist of monounsaturated (52.99 and 56.99 %) for CPH and PKF biodiesels respectively, this is followed by saturated (26.90 and 21.54 %) in CPH and PKF while polyunsaturated fatty acid (20.11 and 21.47%) was the least in both CPH and PKF respectively, Table 2. The major fatty acids in the biodiesels were the oleic, linoleic, palmitic and arachidic acid.

CONCLUSION

Biodiesel have become more attractive because of its environmental benefits and the fact that it is made from renewable resources since the last decade of the last century. *Jatropha curcas* oil was converted to biodiesel using caustic potash from cocoa pod husk (CPH) and palm kernel frond (PKF). The major fatty acids in the biodiesels produced were the oleic, linoleic, palmitic and the arachidic acids. The biodiesels exhibited good physicochemical properties and could be useful as biofuel. These results clearly indicate that there is not only a very good probability of caustic potash being prepared from cocoa pod husks and palm kernel fronds but also the potash can be harnessed for useful purposes. Consequently, there is need to develop a suitable local technology which can be used to extract the caustic potash at the site of productions, and to analyse the samples for the degree of purity. The country can get more tones of caustic potash from over 30000 tons of pod husks that are wasted annually if the agricultural wastes are properly harnessed. There will be drastic reduction in environmental pollution as these wastes are likely to have adverse effect on soil fertility.

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