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Biodiesel Yield from Different Varieties of Castor Seeds Oil

*F. A. Oluwole[1], A. T. Abdulrahim[1], N. A. Aviara[2] and B. Umar[2].
[1]Department of Mechanical Engineering, University of Maiduguri, Maiduguri, Nigeria
[2]Department of Agricultural and Environmental Resources Engineering, University of Maiduguri, Maiduguri, Nigeria
*Corresponding author email: engrfasiu@yahoo.com

Abstract

Mechanically expressed oil from four varieties of castor seeds namely: white big size (WBS), black big size (BBS, grey medium size (GMS) and grey small size (GSS) were converted to biodiesel by reacting the oil with methanol in the presence of potassium hydroxide in a transesterification process. Comparative evaluation was carried out to determine biodiesel yield from the varieties. Results show that the GMS variety gave the highest biodiesel yield followed by the GSS and the BBS with the WBS giving the least yield. The GMS variety, which gave the highest biodiesel yield is recommended for the production of biodiesel.

Keywords: Castor oil, catalyst, methanol, transesterification, biodiesel yield.

INTRODUCTION

The exploitation of renewable and environmental friendly energy resources is increasing globally due to increasing prices, environmental effects (global warming) and uncertainties in the availability of conventional energy resources such as fossil fuels (Anonymous, 2000). Biofuels are alternative renewable sources of energy that are receiving considerable attention the world over (Garba *et al., 2005*). Among the well known biofuels are bioethanol and biodiesel, both of which are used as sources of power for cars, trucks and aircrafts (Garba *et al., 2005*). The world's largest producers of ethanol are Brazil and USA, and of biodiesel are Germany and Austria (Garba *et al.,* 2005). Biodiesel attracts wider interest and more global acceptance because of the diversity of its feedstock and relative ease of production (Bello and Makanju, 2011). Biodiesel fuels have different properties from petroleum diesel, such as higher viscosity, higher Cetane number, higher specific gravity and lower heating value (Graboski and McCormick, 1998) and these differences depend upon the biodiesel feed stocks. In Nigeria, many oil seeds are grown across the country. Some of these oil crops are grown on the cultivated lands while others grow in the wild; and both edible and non-edible oils are obtained from the crops (Anonymous, 2000).

To avoid competition with food crops, the non-edible oil seeds are generally recommended for energy production. The most common of the non-edible oil seeds are Jatropha, castor, and neem seeds (Anonymous, 2000). In this part of the world, research on castor seed and its derivatives has not been fully exploited. Research has shown that deferent varieties of castor seeds are available (Oluwole *et al., 2012*).

Despite the economic importance of these multivarietal seed oil yielding crops available in Nigeria, there have not been comparative studies on the biodiesel yield of the oil. Therefore, there is need to investigate the effect of castor seed variety on the biodiesel conversion of the castor seed oil. This study, therefore, aims at determining the biodiesel yield of oil from different varieties of castor seeds.

MATERIALS AND METHODS

Materials

In this study, the varieties of castor seeds used are white big size (WBS), black big size (BBS), grey medium size (GMS) and grey small size (GSS) as shown in Figure 1, and they were obtained from farmers in Maiduguri, Borno State, Nigeria. Oil was expressed from these varieties using hydraulic press.

Figure 1: Castor seeds: A - White Big Size (WBS); B - Black Big Size (BBS); C - Grey Medium Size (GMS); D - Grey Small Size (GSS)

Methods

Transesterification of castor oil

Castor oil can be converted to biodiesel following the methods described by Conceicao *et al.,* (2007a & b). The transesterification reaction of castor oil was carried out in a developed batch laboratory-scale reactor (Figure 2), with anhydrous methanol, using potassium hydroxide (KOH) as catalyst. Prior to the transesterification reaction process, 500 ml of castor oil was heated to 80ºC for 1hr, (by setting the regulator of the heating mantle to 80ºC) to evaporate water, and then allowed to cool down to room temperature (Deligiannis *et al.* 2009 and Berman *et al,* 2011). The reactor was preheated to about 80^{o}C using heating mantle, to eliminate moisture and then allowed to cool down to room temperature, then 250 ml of castor seed oil was added. The reactor with the oil was reheated, when the reactor and its content reached the reaction temperatures for the experiments (30, 45 or 60^{o}C), the methanol and KOH mixture were added, in the amounts established for the experiment (1, 1.5 or 2% catalyst concentration) by weight of castor oil used, and the stirring mechanism was switched on, taking this moment as time zero of the reaction. Each mixture was vigorously stirred for the required reaction time (15, 30 or 60min), at approximately reaction time; heating and stirring were stopped by switching off the reactor and the heating mantle switches. In all the experiments, a methanol/castor oil molar ratio of 6:1 was used to bias the reaction toward higher yield and because of the very high viscosity of the castor oil (Bello and Makanju , 2011 and Berman *et al,* 2011). This was repeated for all the four varieties.

The products of the reaction were drained off the reactor via the drain outlet by opening the tap into a beaker. This was transferred to separating funnel and allowed to settle overnight producing two distinct liquid phases: crude ether phase (Biodiesel) at the top and glycerol; phase at the bottom (Figure 3).

The crude biodiesel was separated from the glycerol and washed using warm distilled water. The washing was carried out by mixing with 20% volume of warm distilled water in a 500 ml round bottom flask and stirred gently by shaking the flask with hand for 10min. This was allowed to settle and it separated into two layers of pure biodiesel and hydrated methanol with the lighter biodiesel at the top. This was separated using a separating funnel (Figure 4). The procedure was repeated 3 times (Dorado *et al*. 2002 and Deligiannis *et al.* 2009) before being heated to 110^{O}C for 10 min to remove the excess water. The percentage of biodiesel yield was calculated as:

$$\text{Biodiesel yield (\%)} = W_{Biodiesel} / W_{Oil} \times 100\% \quad (1)$$

where $W_{Biodiesel}$ = Total weight of Biodiesel collected, g

W_{Oil} = Total weight of oil sample, g

Figure 2: Batch Reactor used for the biodiesel conversion

Figure 3: Phase separation of biodiesel and glycerine

Figure 4. Phase separated of pure biodiesel and hydrated methanol

RESULTS AND DISCUSSIONS

Biodiesel Yield

The variation of biodiesel yield from four varieties of castor seed oils is presented in Figure 5. It is observed from the Figure that the grey medium size gave the highest biodiesel yield followed by the grey small size, the black big size and the least yield was obtained from the white big size. Biodiesel yield from oil of each variety increased with increase in catalyst concentration except for the grey medium size in which it increased with catalyst concentration up to the concentration of 1.5% and then decreased with further increase in catalyst concentration. This may be due to the fact that the acid value of oil from WBS, BBS and GSS were higher and therefore, required higher percentage of catalyst concentration to produce higher yield of biodiesel. This is in agreement with the findings of Sousa *et al.* (2010), Encinar *et al.* (2010), Panwar *et al.* (2010), Ramezani *et al.* (2010), Berman *et al.* (2011) and Sreenivas *et al.* (2011) on castor oil biodiesel. It can be seen from this table that the effects of reaction time, catalyst concentration and seed variety were statistically significant at 5% level.

Figures 6, 7 and 8 show the effects of seed variety and reaction temperature, reaction time and catalyst concentration respectively on biodiesel yield. It is obvious from these figures that the GMS variety generally gave the highest biodiesel yield followed by the GSS, BBS and the least is from the WBS variety. It is observed in Figure 6 that reaction temperature had no effect on biodiesel yield, but Figures 7 and 8 indicate that reaction time and catalyst concentration respectively had effects on biodiesel yield. This is in agreement with the findings of Da Silva *et al.*(2006) on castor oil biodiesel

CONCLUSION

In this study, oils from four varieties of castor seeds were converted to biodiesel via transesterification process. Investigation was carried out to determine the variety that gives optimum biodiesel yield and the following conclusions were derived:

1. GMS variety gave the highest biodiesel yield followed by the GSS, the BBS and the least was from the WBS variety.

2. Reaction temperature (A) had no significant effect on the biodiesel yield of the from the four castor seed varieties.

3. Reaction time (B), catalyst concentration (C) and their interaction (BC) significantly affected the biodiesel yield of the four castor seed varieties.

4. GMS variety, which gave the highest biodiesel yield is recommended for the biodiesel production.

REFERENCES

Akpan, U. G., Jimoh, A.and Mohammed, A. D. (2006). Extraction, Characterization and Modification of Castor Seed Oil. *Leonardo Journal of Sciences 8: 43-52.*

Anonymous. (2000). Castor bean, castor oil plant. http://www.vet.perdue.edu/depts/addl/toxic/ *plant11.htm*. Referred on 12th march, 2008.

Bello E.I. and Makanju A.(2011). Production, Characterization and Evaluation of castor oil Biodiesel as Alternative Fuel for Diesel Engines. *Journal of Emerging Trends in Engineering and Applied Sciences 2(3): 525-530.*

Berman, P., Nizri, S. and Wiesman, Z. (2011). Castor Oil Biodiesel and its Blend as Alternative Fuel. *Biomass and Bioenergy. 35:2861-2866.*

Chakrabarti, M. H. and Rafiq, A. (2008). Transesterification Studies on Castor Oil as a First Step Towards its Use in Biodiesel Production. *Pakistan Journal Bot., 40 (3): 1153-1157.*

Conceicao, M. M., Candeia, R. A., Silva, F. C., Bezerra, A. F., Fernandes Jr., V. J. and Souza, A. G. (2007a). Thermoanalytical Characterization of Castor Oil Biodiesel. *Renewable and Sustainable Energy Reviews.* 11(5): 964-975.

Conceicao, M. M., Fernandes Jr., V. J., Bezerra, A. F., Silva, M.C.D., Santos, I.M.G., Silva, F. C., and Souza, A. G. (2007b). Dynamic Kinetic Calculations of Castor Oil Biodiesel. *Journal of Thermal Analysis & Cal.* 87: 865-869.

Da Silva Lima, N.; Wolf Maciel, M.R.; Batistella, C.B. and Filho, R.M. (2006). Optimization of

Biodiesel Production From Castor Oil. *Applied Biochemistry and Biotechnology 129-132.*

Deligiannis, A., Anastopoulos, G., Karavalakis, G., Mattheou, L., Karonis, D., Zannikos, F., Stournas, S. and Lois, E. (2009). Castor (Ricinus Communis L) Seed Oil as an Alternative Feedstock for the Production of Biodiesel. *Proceedings of the 11th International Confrence on Environmental Science and Technology.* Chania, Crete, Greece. 3 – 5 September 2009.

Dorado, M.P., Arnal, J.M., Gomex, J., Gill, A. and Lopez, F.J. (2002). The Effects of a Waste Vegetable Oil Blend with Diesel Fuel on Engine Performance. *Transactions of ASAE*, 45 (3): 519-523.

Encinar, J.M., Gonzalez, J.F., Martinez, G., Sanchez, N. and Gonzalez, C.G. (2010). Synthesis and Characterization of Biodiesel Obtained from Castor Oil Transesterification. International Conference on Renewable Energy and Power Quality (ICREPQ 11). Spain 13th – 15th April 2010.

Garba, U.M.; Alhassan, M. and Kovo, S.A. (2005). A Review of Advances and Quality Assessment of Biofuels. *Leonardo Journal of Science 9: 167-178.*

Graboski, M.S. and McCormick, R.L. (1998). Combustion of Fat and Vegetable Oil Derived Fuels in Diesel Engines. *Prog. Energy Combust. Sc., 24: 125-164.*

Graboski, M.S.; Ross, J.D. and McCormick, R.L. (1996). Transient Emissions from No.2 Diesel and Biodiesel Blends in a DDC Series 60 Engine. *SAE Technical Paper 961166.*

McCormick, R.L.; Graboski, M.S.; Herring, A.M. and Alleman, T.L. (2001). Impact of Biodiesel Source Material and Chemical Structure on Emissions of Criteria Pollutions from a Heavy-duty Engine. *Environmental Science and Technology. 35 (9): 1742-1747.*

Mu'azu, K., Mohammed-Dabo, I.A. and Waziri, S.M. (2012). Development of Mathematical Model for the Prediction of Essential Oil Extraction from *Eucalyptus Citriodora* Leave. *Journal of Basic and Applied Scientific Research, 2 (3) 2298-2306.*

Oluwole, F.A., A.T. Abdulrahim, N.A. Aviara and Nana S. Ndahi. (2012). Traditional Method of Extracting Castor Oil. *Continental Journal of Engineering Sciences, 7 (2): 6 -10.*

Oluwole, F.A., Aviara, N.A., Umar, B. and Umara, B.G. (2014). Influence of Variety on Oil Yield and Oil Recovery of Castor Seed. *Continental Journal of Engineering Sciences, 9 (1): 9 -18.*

Panwar, N. L. and Shrirame, H. Y., Rathore, N.S., Jindhakar, S. and Kurchania, A.K. (2010). Performance Evaluation of a Diesel Engine Fueled with

Methyl Ester of Castor Seed Oil. *Applied Thermal Engineering, 30: 245-249.*

Remezani, K., Rowshanzamir, S. and Eikani, M.H. (2010). Castor Oil Transesterification Reaction: A kinetic study and optimization of parameters. Energy 35, 4142-4148.

Silva, G. F., Camargo, F. L. and Ferreira, A. L. O. (2011). Application of Response Surface Methodology for Optimization of Biodiesel Production by Transesterification of Soybean Oil with Ethanol. *Fuel Processing Technology.* 92: 409-413

Souse, L.L, Lucena, I.L. and Fernandes, F.A.N. (2010). Transesterification of Castor Oil: Effect of the Acid Value and Neutralization of the oil with Glycerol. *Fuel Processing Technology, 91:194-196.*

Sreenivas, P., Mamilla, V.R and Sekhar, K.C. (2011). Development of Biodiesel from Castor Oil. International Journal of Energy Science. Vol. 1 No 3. 192-197.

Suresh, B.; Viruthagiri T. and Sasikumar, E. (2009). Optimization of Process Variables Using Response Surface Methodology (RSM) in the Solid-state Fermentative Production of Pectinase by Aspergillus Awamori. *Asian J. Food Ag-Ind. 2(03), 302-314*.

Tat, M.E. and Van Gerpen, J.H. (2000). The Specific Gravity of Biodiesel and its Blends with Diesel Fuel. *J. Am. Oil Chem. Soc. 77 (2): 115-119*.

Tiago Almeida Silva; Antonio Carlos Ferreira Batista; Andressa Tironi Vieira; Marcelo Firmino de Oliveira (2013). A Simple Method for the Biodiesel Production by the Reuse of Different Types of Waste Frying Oils. *Advances in Petroleum Exploration and Development, 5 (2): 83-88.*

Yuan, W.; Alan, Hansen, A.C. and Zhang, Q. (2004). The Specific Gravity of Biodiesel Fuels and Their Blends with Diesel Fuel. *Agricultural Engineering International: the CIGR Ejournal of Scientific Research and Development. Manuscript EE 04 004. Vol VI September, 2004*.

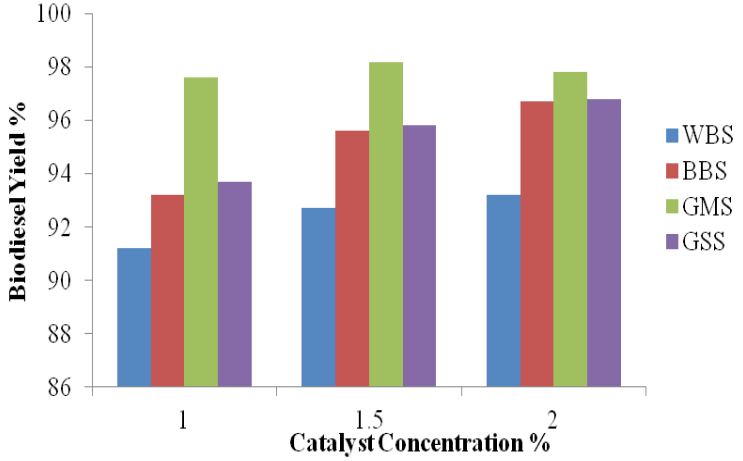

Figure 5: Biodiesel yield from raw undehulled castor oils at the optimum reaction time of 60 min and reaction temperature of 60^{O}C

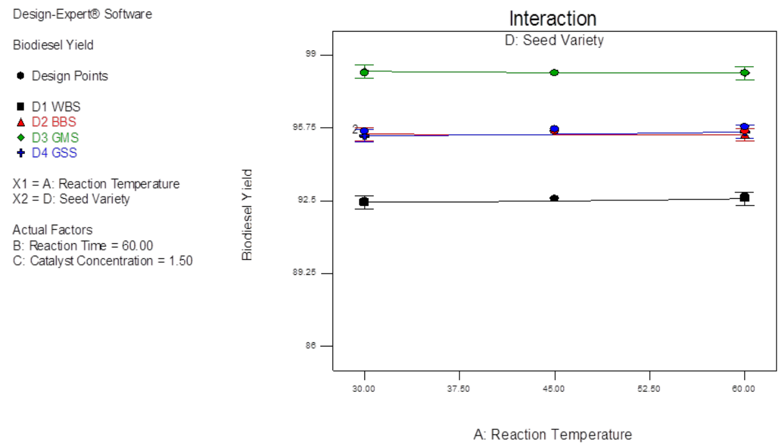

Figure 6: Biodiesel yield vs seed variety and reaction temperature

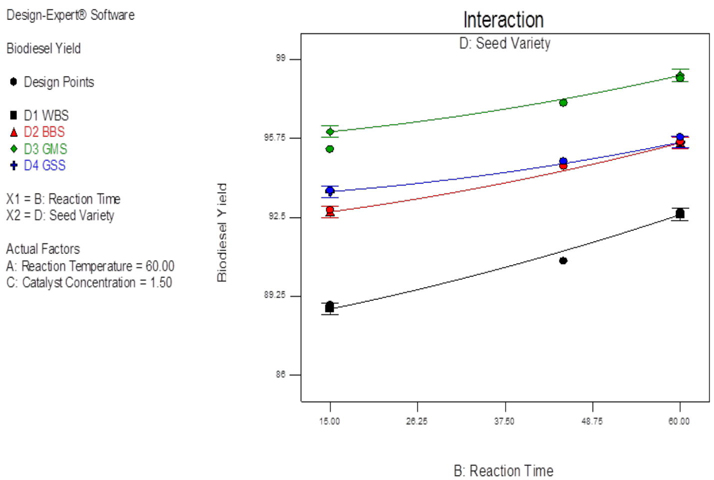

Figure 7: Biodiesel yield vs seed variety and reaction time

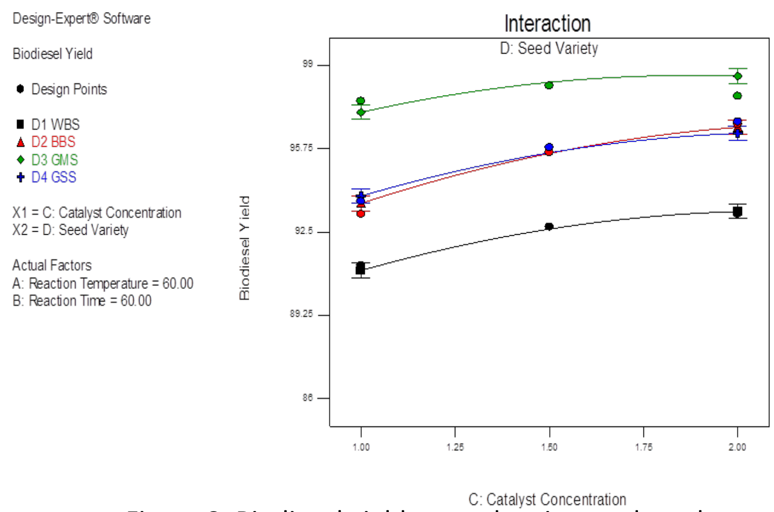

Figure 8: Biodiesel yield vs seed variety and catalyst concentration