Gezira j. of Eng. & applied. Sci. 12-(1): 59-67 (2017)

Production of Biodiesel from *Jatropha curcas* Seed Oil

Maha A. A. Abdelrahman[1]*, Atif A. A. Yassin[1], Ismail Hassan Hussein [1], Mohamed E.S. Mirghani [2] and Abdallah B. Karama [3]

1- National Oilseed Processing Research Institute (NOPRI), University of Gezira, P.O.Box (20), Medani, Sudan.
2- International Islamic University Malaysia, Department of Biotechnology Engineering, Faculty of Engineering.
3- Karary University, Khartoum, Sudan.

***Email**: maha.nopri2010 @ uofg.edu.sd

ABSTRACT

This study was carried out to produce biodiesel from freshly harvested *Jatropha curcas* (*J. curcas*) seed oil. *J. curcas* seed oil has a high oil content (40%), the free fatty acids (FFA) range is (1.6-1.75%), peroxide value is 2.6 meq/kg, oil moisture content range is (0.2-0.3%) and saponification value range is (185-189) mg KOH/g oil. The main fatty acids are oleic 39.60 % and linoleic acids 34.64 %, unsaturated fatty acids in J. curcas oil are 75.54 wt%, while, saturated fatty acids are 24.46 wt%. The specifications of biodiesel produced are; Density is reduced from 0.9198 to 0.8810 g/cm^3. The kinematic viscosity at 40 ^{o}C was reduced from 36.37 to 4.809 mm^2/s, and the flash point is 187^{o}C. Biodiesel produced complies with the requirements of the American Society for Testing and Materials (ASTM) standard D6751-09, and the Committee of Standardization in Europe (CEN) standard EN 14214 specifications.

Keywords: ***Biodiesel, J. curcas, Biodiesel standards***

INTRODUCTION

Biodiesel is an alternative for fossil fuel that can be commercially produced through transesterification of vegetable oils with short chain alcohols (usually methanol or ethanol) in the presence of an alkali catalyst to transform the triglyceride molecules into smaller, straight chain molecules of fatty acid methyl or ethyl esters (Yuan *et al*., 2009; Wang *et al.* 2010; Noureddini *et al.*, 2009).

Vegetable oils are promising feedstocks for biodiesel production and have become more attractive recently. They are renewable, biodegradable and environmentally friendly. The most common vegetable oils for producing biodiesel are soybean in the United States of America and Brazil, palm oil in Southeast Asia, jatropha in India, rapeseed in Eastern Europe and crops such as sunflower, camelina and hazelnuts in the United States. Utilizing edible oils for biodiesel production is expected to create a shortage supply of food for human consumption; this makes non edible oils such as *J. curcas* oil to be promising feedstocks for biodiesel production (Patil and Deng, 2009; Koh and Ghazi, 2011; Erhan, 2005; Kurki *et al*., 2006; Azam *et al*., 2005; Charlene *et al*., 2004).

J. curcas L. (popularly known as physic nut, pinoncillo, habb-el-mueluk, purging nut, barbados purging nut, ratanjyot etc.) belongs to the euphorbiaceae family. It is considered to be native to Central and South America and is widely present throughout Central America, Africa and Asia; varying with different genotype, one being toxic and the other is nontoxic. The non-toxic genotype is present only in Mexico (Devappa *et al*., 2010; Rao *et al*., 2009; Becker and Makkar, 2008).

J. curcas is a vigorous, drought and pest resistance plant, and can grow under a wide range of rainfall regimes ranging from 200mm to over 1,500 mm per annum. It survives also in barren, eroded lands and under harsh climate conditions. The *J. curcas* seeds become capable of having their oil extracted after 2-5 years of plantation depending on the soil quality and rainfall and the plant has a productive life of 40- 50 years. *J. curcas* oil is non edible due to the presence of anti-nutritional factors such as phorbol esters, which makes it attractive for biodiesel production (Makkar *et al.*, 2009; Becker and Makkar, 2008; Gubiz *et al*., 1999; Gubiz *et al.*, 1997). This work aims to produce biodiesel from *J. curcas* seed oil.

MATERIALS AND METHODS

J. curcas seed was obtained from Western Sudan (Abu Karshola) and extracted mechanically in a bench scale expeller (OEKO TEC- IBG MONFORTS, Type CA 59 G, 2006, Machine No. 20 201550- Germany).
Oil content was determined according to the American Oil Chemists Society (AOCS) official method Aa 4-38, Ab 3-49 and Am 2-93, revised (2000). FFAs were determined according to the AOCS official method Ca 5a-40. Saponification value was determined according to the AOCS official method Cd 3-25. Peroxide value was determined according to the AOCS official method Cd 8-53. Moisture and volatile matter was determined according to the AOCS official method Ba 2a-38.

The fatty acid composition of the methyl ester (biodiesel) of *J. curcas* was determined using GC/MS with auto-sampler (Agilent Technologies 7890A gas chromatograph equipped with 5975C mass spectrometer) under the following conditions: column: DB wax 122–7032 (length: 30 m, film thickness: 0.25 and an internal diameter: 0.25 mm), carrier gas: helium, flow rate: 1 ml/min, column temp.: 50 ^{o}C; run time: 35 min, injection volume: 1 μl .
Biodiesel production was carried out in a 1000 ml three-neck round flat bottom flask, equipped with a reflux condenser; the flask was placed on a hot plate equipped with a magnetic stirrer and temperature controller. *J. curcas* oil was dried by heating the oil to 110 ^{o}C, and cooling to 60 ^{o}C. Methoxide solution was added to the *J. curcas* oil and heated to 65 ^{o}C at 600 rpm for one hour. The reaction was conducted using different methanol to oil molar ratios at different catalyst to oil ratios. After the reaction was completed, the product was transferred into a separatory funnel to overnight. Then the glycerol at the bottom layer was separated. The biodiesel at the top layer was washed using hot distilled water at 60 ^{o}C (twice or three times) and the moisture was removed by heating at 110 ^{o}C.

The kinematic viscosity was determined according to the American Society of Testing and Materials ASTM method number D445 (2004). The Flash point was determined according to ASTM method number D93 2002a. The density was determined according to (ASTM) method number D4052-96 (Reapproved 2002). The pour point was determined according to (ASTM) method number D97-04.

RESULTS AND DISCUSSION

Table (1) illustrates the characteristics of the *J. curcas* oil used, *J. curcas* seeds have high oil content (40%), which makes *J. curcas* more attractive as biodiesel feedstocks. FFA range is (1.6-1.76%).The saponification value of *J. curcas* oil varies from 185 to 189 mg KOH/g.

Table (1): Characteristics of *J. curcas* Oil

Parameters	Value
Oil content (%)	39.5±0.5
Free fatty acid, FFA (%)	1.6-1.75
Peroxide value (meq/kg)	2.6
Seed moisture content (%)	3.2
Oil moisture content	0.2
Saponification value (mg KOH/g oil	185-189

Table (2) shows the fatty acid composition of *J. curcas* oil, the results show that the main fatty acids are oleic and linoleic acids. On the other hand, unsaturated fatty acids in *J. curcas* oil are 75.54 wt%, while, saturated fatty acids are 24.46 wt%. The fatty acid composition agrees with that of (Gubiz *et al*.,1999).

Table (2): Fatty Acid Composition of *J. curcas* Oil

Fatty acid	Formula	Systematic name	Structure	This Study	Gubiz *et al.*, (1999)
Myristic	$C_{14}H_{28}O_2$	Tetradecanoic	14:0	0.07 ± 0.01	0-0.1
Palmitic	$C_{16}H_{32}O_2$	Hexadecanoic	16:0	16.74 ± 0.1	14.1-15.3
Palmitoleic	$C_{16}H_{30}O_2$	cis-9- Hexadecenoic	16:1	1.10 ± 0.05	0-1.3
Margaric	$C_{17}H_{34}O_2$	heptadecanoic	17:0	0.10 ± 0.0	-
Stearic	$C_{18}H_{36}O_2$	Octadecanoic	18:0	7.34 ± 0.1	3.7-9.8
Oleic	$C_{18}H_{34}O_2$	cis-9-Octadecenoic	18:1	39.60 ± 0.05	34.3-45.8
Linoleic	$C_{18}H_{32}O_2$	cis-9,cis-12—Octadecedianoic	18:2	34.64 ± 0.1	29.0-44.2
Linolenic	$C_{18}H_{30}O_2$	cis-6,cis-9,cis-12-Octadecatrienoic	18:3	0.20 ± 0.005	0-0.3
Arachidic	$C_{20}H_{40}O_2$	Eicosanoic	20:0	0.21 ± 0.1	0-0.3
Behenic	$C_{22}H_{44}O_2$	Docosanoic	22:0	-	0-0.2

Table (3) shows the biodiesel specifications, Density is reduced from 0.9198 to 0.8810 g/cm^{3}and heavy glycerin was removed. The kinematic viscosity at 40 ^{o}C was reduced from 36.37mm^2/s to 4.809 mm^2/s, that within the range of ASTM (1.9-6mm^2/s) and EN (3.5- 5mm^2/s). The flash point is 187^{o}C which is more than 130^{o}C for ASTM D6751-02 and 101 ^{o}C for EN 14214 specifications. Therefore, the biodiesel produced complies with the requirements of the American Society for Testing and Materials (ASTM) standard D6751-09, and the Committee of Standardization (CEN) standard EN 14214 specifications.

Table (3): Fuel Properties

property	**Unit**	**JCO**	**JCB**	**ASTM D6751-02**	**EN 14214**
Density at 15 ^{o}C	g/cm^3	0.9198	0.8810	0.875-0.900	0.860-0.900
Kinematic Viscosity at 40^{o}C	mm^2/s	36.37	4.809	1.9-6.0	3.5-5.0
Flash point	^{o}C	195	187	130 min	101 min
Pour point	^{o}C	+5	+5	-	-
Sulfur content	%	-	0.0042	0.05	10 max

Note : JCO= *J. curcas* oil, JCB= *J. curcas* biodiesel

CONCLUSIONS

J. curcas seed oil is an attractive feedstock for biodiesel production, the seed has high oil content about 40%, moreover, the properties of biodiesel produced agree with the American Society for Testing and Materials (ASTM) standard D6751-09, and the Committee of Standardization in Europe (CEN) standard EN 14214.

ACKNOWLEDGMENTS

This work was conducted under the financial support of National Oilseed Processing Research Institute (NOPRI) - University of Gezira and DAAD. We also wish to gratefully acknowledge International Islamic University Malaysia (IIUM) and University of Malaya- Centre for Ionic Liquids (UMCiL) for their encouragement and permission to conduct the research with their facilities.

REFERENCES

Azam M. M., Waris A., Nahar N. M., (2005), Prospects and Potential of Fatty Acid Methyl Esters of some Non-traditional Seed Oils for use as Biodiesel in India. Biomass Bioenergy 29: 293-302.

Becker K. and Makkar H. P. S., (2008), *Jatropha curcus*: A Potential Source for Tomorrow's Oil and Biodiesel, Lipid Technol. 20:104-107.

Charlene A., Markolwsi W., Kichere A., Saling P., (2004), Using eco-efficiency Analysis to Assess Renewable Resource Based Technologies. Environ Prog 23: 329- 333.

Devappa R. K., Maes J., Makkar H. P. S., De Greyt W. and Becker K., (2010), Quality of Biodiesel Prepared from Phorbol Extracted *Jatropha curcus* Oil, J. Am. Oil Chem. Soc. 87:697-704.

Erhan S. Z., (2005), Industrial Uses of Vegetable Oils, Food and Industrial Oil Unit, printed in the United States of America.

Gubiz G. M., Mittelbac M. and Trabi M., (1997), Biofuels and Industrial Products from *J.curcas*, In: Symposium "Jatropha 97", Managua, Nicaragua.

Gubiz G. M., Mittelbac M. and Trabi M., (1999), Exploitation of the Tropical Oil Seed Plant *Jatropha curcas* L, Bioresource Technology 67:73-82.

Koh M. Y. and Ghazi M., (2011), A review of Biodiesel Production from Jatropha curcas Oil. Renewable and Sustainable Energy Reviews. 15(5): 2240-2251.

Kurki A., Hill A. and Morris M., (2006), Biodiesel: The Sustainability Dimensions. National Sustainable Agriculture Information Service. http://www. Attar.ncat.org/attar-pub/Pdf/ biodiesel – sustainable pdf (accessed May 2008).

Makkar H., Maes J., De Greyt W. and Becher K., (2009), Removal and Degradation of Phorbol Esters during Pre-treatment and Transesterification of *Jatropha curcas* Oil, J. Am. Oil Chem. Soc. 86:173-181.

Noureddini H., Bandlamudi S. R. P. and Guthrie E. A., (2009), A Novel Method for the Production of Biodiesel from the Whole Stillage Extracted Corn Oil. J. Am. Oil Chem. Soc. 86:83-91.

Patil P. D. and Deng S., (2009), Optimization of Biodiesel Production from edible and non-edible vegetable oils, fuels; 88:1302-1306,

Rao K. S., Chakrabarti P. P., Rao B. V. S. K. and Parasad R. P. N., (2009), Phospholipid Composition of *Jatropha curcus* Seed Lipids, J. Am. Oil Chem. Soc. 86:197- 200.

Wang H., Tang H. and Sally S., (2010), Analysis of Sterol Glycosides in Biodiesel Precipitates, J. Am. Oil Chem. Soc., 87: 215-212.

Yuan H., Yang B., and Yang J., (2009), Predicting Properties of Biodiesel Fuels using Mixture Topological Index, J. Am. Oil Chem. Soc., 86: 375- 382.