African Journal of Biotechnology Vol. 11(83), pp. 14930-14933, 16 October, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB12.2132

Full Length Research Paper

Physicochemical characterization of *Quassia undulata* seed oil for biodiesel production

IKO, Wanen and EZE, Sabinus Oscar O.*

Department of Biochemistry, University of Nigeria Nsukka, Nigeria.

Accepted 25 July, 2012

In many parts of the world, there is a surplus of traditional crops and a continuous search for break and new crops, including some which produce useful oils. *Quassia undulata* seed oil is such an attractive resource. This present research was carried out to assess the physicochemical properties of the oil from *Q. undulata* seeds extracted using normal-hexane as solvent. *Q. undulata* seeds had a high yield comparable to those of palm fruit and cotton seed. The physicochemical characterization indicated specific gravity (1.099), iodine value (132.78), acid value (3.759) and peroxide value (6.756). The values obtained from *Q. undulata* were uniquely different from common vegetable oils but with a superior combination of properties to suit a promising industrial process such as biodiesel production.

Key words: *Quassia undulata*, physicochemical properties, vegetable oil, biodiesel production.

INTRODUCTION

Developed countries of the world consume much more fossil fuel and fossil derived products than they could extract from their territory, thereby making them dependent on foreign supplies. This dependency on fossil fuel which is non-renewable has lead to increasing pollution and costs, consequently; there is a need for an alternative source of energy which has lead to an increasing need to search for oils from vegetative sources to augment the available ones and also to meet specific applications (Kyari, 2008). In search for new energy sources, much attention is focused on oils as a reliable and renewable resource. Currently, biodiesel is considered a real alternative to diesel fuel due to its environmental benefits and renewability (Alamu et al., 2008; Adebayo et al., 2011; Demirbas and Karslioglu, 2007).

The high cost of vegetable oil is the most important issue in the economic evaluation of the biodiesel process. Reducing the cost of the feedstock is necessary for biodiesel's long-term commercial viability (Demirbas and Karslioglu, 2007). In order to achieve production cost reduction and make biodiesel more competitive with petroleum diesel, low cost feedstocks such as non-edible oils could be used as raw material (Fan et al., 2009).

In recent years, there are growing concerns about the utilization of non-edible oils for the generation of alternative source of energy (Singh and Siroj, 2009). *Jatropha curcas* has tremendous potential for biodiesel production. Other non-edible oils like *Pongamia pinnata*, *Argemone*, castor and Sal are also being investigated (Vasudevan and Briggs, 2008), yet the demand far exceeds the current and future production capacities of the vegetable oil and animal fat industries (Xu and Hanna, 2009).

New oil seed crops are needed to meet existing energy demands (Gunstone, 1999) as such oils, mostly produced by seed-bearing trees and shrubs with no competing food uses, can provide an alternative. This characteristic has turned our attention to *Quassia undulata.*

Q. undulata is a perennial shrub distributed in tropical and subtropical Africa, America, Asia and Australia. *Q. undulata* is a fast growing shrub that has been variously reported to have poisonous seeds which may be due to its rich alkaloids. Louppe et al. (2008) reported that *Q. undulata* seeds have an oil yield of 56%. *Q. undulata* seed oil has both saturated and unsaturated fatty acids in a blend which makes the spectrum of considerable potential for biodiesel production. Oleic acid, which has been reported as having the highest influence on the

***Corresponding author. E-mail: sabinus.eze@unn.edu.ng, ezeaug22@yahoo.com. Tel: +2347066090552.

Table I. Physicochemical properties of *Q. undulata* seed oil.

S/N	Parameter	Value
1	Colour	Golden yellow
2	Taste	Bitter
3	Odour	Agreeable odour
4	Physical state at room temperature	Liquid
5	Percentage oil yield	35.07
6	Specific gravity	1.099
7	Viscosity (mm^2/s)	7.401
8	Flash point (°C)	340
9	Moisture content (%)	5.80
10	Ash content (%)	1.36
11	Refractive index	0.7142
12	Cloud point (°C)	18.5
13	Iodine value (gI_2/100g of oil)	132.78
14	Peroxide value (mg Eq/kg)	6.758
15	Acid value (mg NaOH/g of oil)	3.759
16	Saponification value (mg KOH/g of oil)	93.266

properties of oil for biodiesel production (Raja et al., 2011) has the percentage composition of 46 to 61% in *Q. undulata* seed oil which makes it a promising alternative crop for biodiesel production.

The aim of this study was to evaluate for the first time, selected physicochemical properties of *Q. undulata* seed oil with the bias for its utilization in biodiesel production.

MATERIALS AND METHODS

Collection and processing of sample

Q. undulata seeds used for this experiment were collected from Yandev town of Gboko local government area, Benue state, Nigeria. The *Q. undulata* seeds were identified at the Forestry Department of Akperan Orshi College of Agriculture Yandev by Mr. Solomon Igah. The nuts were broken and the seeds removed. The seeds were cleaned by washing with distilled water and dried in an oven at 40°C for approximately 72 h. The seeds were ground with a blender into course particles and ready for oil extraction.

Extraction of oil from *Quassia undulata* seed

Seeds (500 g) were crushed, using commercial grinder and feed to a Soxhlet extractor fitted with a 2-L round bottomed flask (Rashid et al., 2008). The extraction was executed on a water bath for 6 h, with n-hexane. The solvent was removed under vaccum, using a rotary evaporator. The amount of oil extracted was determined using the equation as follows:

$$\text{Oil content (\%)} = \frac{\text{Weight of oil extracted}}{\text{Weight of seeds}} \times 100$$

Physicochemical analysis of *Quassia undulata* seed oil

Physicochemical properties were determined by using standard test methods. These standard values were calculated and compared with European organization (EN 14214).

Refractive index (at room temperature), was determined with Abbe refractometer (Alamu et al., 2008), specific gravity measurement (also at room temperature), using specific gravity bottle (Bagali et al., 2010). Other parameters such as flash point, moisture content, ash content and cloud point were determined, following the method described by the Association of Official Analytical Chemists (AOAC) (1984). Iodine, peroxide, acid and saponification values were determined as described by Hamilton and Hamilton (1992).

RESULTS AND DISCUSSION

Percentage yield of oil

Q. undulata seeds gave an oil yield of 35.07% (Table 1). Oil content of *Q. undulata* was found higher than those of linseed (33.33%), soybean (18.35%) (Gunstone, 1999), and *Amaranthus hybridus* (13.95%) (Dhellot et al., 2006). High oil content of *Q. undulata* seeds indicated that *Q. undulata* are suitable as non-edible vegetable oil feed stock for the commercial production of biodiesel.

Physical and chemical properties

The physicchemical properties are shown in Table 1. The specific gravity of *Q. undulata* seed oil (1.009) is higher than the specific gravity of common oil seeds such as *J. curcas* (0.901) (Belewu et al., 2010), shea butter (0.902) (Asuquo and Anusiem, 2010) and fluted pumpkin (0.908) (Ibeto et al., 2011). Specific gravity and refractive index measurements rarely provide sufficient information to quantitatively identify a pure analyte, but are highly useful to check oil contamination/adulteration (Parthiban, 2010).

Higher iodine values indicate higher unsaturation of fats and oils (Akbar et al., 2009). The iodine value of *Q. undulata* seed oil was determined at 132.78. Iodine value of *Q. undulata* was comparable to the values of safflower oil (145 gI_2/ 100 g) and soyabean oil (132 gI_2/100 g) (Eromosele et al., 1993) and was higher than those of *J. curcas* (101.7) and shea butter (65.45) as reported by Raja et al., (2011) and Asuquo and Anusiem, (2010), respectively. The oil shows a high iodine value due to its high content of unsaturated fatty acids. Hence, the oil has a greater potential as a low viscosity and high lubricity biodiesel (Parthiban, 2010). The iodine value has also found applications to various chemical and physical properties of fats and oils which include serving as a quality control method for hydrogenation, applications in standards for biodiesel and in assessing oxidative stability (Nayak and Patel, 2010). Flash point varies inversely with the fuel's volatility. The flash point of *Q. undulate* was determined at 340°C which is above the minimum standard flash point value (>120) for Europe EN 14214 specification. The fundamental reason for measuring flash point is to assess the safety hazard of a liquid with regard to its flammability and then classify the liquid into a recognized hazard group. This classification is used to warn of a risk and to enable the correct precautions to be taken when manufacturing, storing, transporting or using the liquid (Belewu et al., 2010). *Q. undulata* seed oil has a flash point that falls under non-hazardous category, therefore, the higher value reported in this study shows that the oil is safe for usage.

The usual method of assessment of hydroperoxides (primary oxidation products) is by determination of peroxide value (Gunstone, 1999). The peroxide value of *Q. undulata* seed oil is (6.758 mEq/kg). This value is below 10 which characterize majority of conventional oils (Dhellot et al., 2006). The peroxide value of *Q. undulata* oil is relatively lower than that of *Hematostaphis berteri* seed oil (27.5 mEq/kg) and shea butter oil (14.2 mEq/Kg) (Asuquo and Anusiem, 2010), proving the oxidative stabilities of the seed oil relatively.

A fuel property that is particularly important for the low temperature operability of biodiesel fuel is the cloud point, defined as the lowest temperature at which wax crystals begin to form in the fuel. Therefore, it is an index of the lowest temperature of the fuel's usability for certain applications. The cloud point of *Q. undulata* (18.5°C) is high as compared to those of cottonseed, peanut and sunflower which is 1.7, 12.8 and 7.2, respectively (Singh and Siroj, 2009). This indicates that operating at temperatures below the cloud point of oils with high cloud point values (babassu, palm and safflower) can result in fuel filter clogging due to the wax crystals.

The saponification value obtained for *Q. undulata* seed oil (93.266 mgKOH/g) is lower than those of common seeds such as *J. carcus* (202.40 mgKOH/g), linseed oil (195 mgKOH/g) (Singh and Siroj, 2009) and fluted pumpkin (151.48 mgKOH/g). An earlier report by Louppe et al. (2008) showed that *Q. undulata* is composed of fatty acids between C16–C18 which confirms its potential to be used as raw material for biodiesel production.

The ash content of *Q. undulata* seed oil determined at 1.36% is lower than those of almond nut, castor seed, palm kernel, groundnut which is 4.6, 2.8, 1.9, 1.7 and 2.7, respectively (Afolabi, 2008) and *J. carcus* (4.5) (Singh and Siroj, 2009). High concentrations of these materials can cause injector tip plugging, combustion deposits and injection system wear. The low ash content of *Q. undulata* seed oil is an important determinant of the heating value, as heating value decreases with increasing ash content.

The acid value for *Q. undulata* seed oil (3.75 mgNaoH/g) is comparable to that of *A. hybridus* oil (3.76 mg NaOH/g) and fluted pumpkin oil (0.44 mgNaoH/g) (Ibeto et al., 2011). The high acid value of *Q. undulata* seed oil indicates that the oil contains high amount of free fatty acids and pretreatment is necessary for biodiesel production (Mehdi and Hamid, 2011).

Viscosity increases with molecular weight but decreases with increasing unsaturation level and temperature (Akbar et al., 2009). The viscosity is important in determining optimum handling, storage, and operational conditions. The viscosity of *Q. undulata* seed oil (7.4 mm^2/s) must be reduced for biodiesel application since the viscosity of *Q. undulata* was high compared to the standard viscosity value of biodiesel for Europe's EN 14214 specifications. High viscosity of the *Q. undulata* seed oil is not suitable for its use directly as engine fuel. High viscosity often results in operational problems such as carbon deposits, oil ring sticking, and thickening and gelling of lubricating oil as a result of contamination by the vegetable oils (Akbar et al., 2009).

Conclusion

In this present investigation, the physiochemical characterization of *Q. undulata* seed oil has highlighted the potential of this oil as a very good resource. The oil yield of *Q. undulata* seeds is significant to make this resource economically attractive. Therefore, it is amiable to have more research on *Q. undulata* seed oil in the future especially in modifying it for the production of biodiesel.

ACKNOWLEDGEMENT

The authors wish to thank Eze Francisca O, of Dean's office, Faculty of Biological Sciences, University of Nigeria, Nsukka for typing the manuscript.

REFERENCES

Adebayo GB, Ameen OM, Abass LT (2011). Physicochemical properties of biodiesel produced from Jatropha curcas oil and fossil diesel. J. Microbiol. Biotechnol. Resour. 1:12-16.

Akbar E, Yaakob Z, Kamarudin S, Ismail M (2009). Characterization and composition of *Jatropha curcas* oil seed from Malaysia and its potential as biodiesel feedstock. Eur. J. Sci. Res. 29:396-403.

Alamu OJ, Akintola TA, Enweremadu A, Adeleke AE (2008). Characterization of palm-kernel oil biodiesel through NaOH catalysed transesterification process. Sci. Res. Essay 3:308-311.

AOAC (1984). Association of official analytical chemists official methods of analysis.14 ed, Arlington, VA 67:503-515.

Asuquo JE, Anusiem ACI (2010). Extraction and characterisation of shea butter oil. World J. Appl. Sci. Technol. 2:282-288.

Afolabi S (2008). Chemical qualities of oils from some fresh and market vegetable crops within Kwara State of Nigeria. Biokemistri. 20(2):71-75.

Bagali S, Shridhar KV, Beena MV, Paramjeet KB (2010). Optimization and characterization of castor seed oil. Leonardo J. Sci. 17:59-70.

Belewu MA, Adekola F, Adebajo GB, Ameen OM, Muhammed NO, Olaniyan AM, Adekola OF, Musa AK (2010). Physico chemical characterization of biodiesel from Nigerian and Indian *Jatropha Curcas* seeds. Int. J. Biol. Chem. Sci. 4(2):524-529.

Demirbas A, Karslioglu V (2007). Biodiesel production facilities from vegetable oils and animal fats. Energy Sour. 29:133-141.

Dhellot JR., Matouba E, Maloumbi P (2006). Extraction, chemical composition and nutritional characterization of vegetable oils: case of *Amaranthus hybridus* (var 1 and 2) of Congo Brazzaville. Afr. J. Biotechnol. 5(11):1095- 1101.

Eromosele IC, Eromosele CO, Akintoye B, Komolafe IO (1993). Characterization of oils and chemical analysis of the seeds of wild plants. Plant foods Hum. Nutr. 46:361-365.

Fan X, Burton R, Austic G (2009). Preparation and characterization of biodiesel produced from recycled canola oil. Open Fuel Energy Sci. J. 2:113-118

Gunstone FD (1999). Fatty acid and lipid chemistry. Aspen publishers Gaithersburg, Maryland.

Hamilton RJ, Hamilton S (1992). Lipid analysis: A practical approach. Oxford Univ. Press, Walton Street, Oxford.

Ibeto CN, Ofoefule AU, Azeugeu HC (2011). Fuel quality assessment of biodiesel production from groundnut oil (*Arachis hypogeal*) and its blends with petroleum diesel. Am. J. Food Technol. 6:798-803.

Kyari MZ (2008). Extraction and characterization of seed oils. Int. Agrophysics 22:139-142.

Louppe DO, Amoako AA, Brink M (2008). Plant resources of tropical Africa Vol. 7(1). Backhuys Publishers, Leiden, Netherlands.

Nayak B, Patel K (2010). Physicochemical characterization of seed and seed oil of *Jatropha curcas* collected from Bardoli (South Gujarat). Sains Malaysiana 39:951-955.

Mehdi A, Hamid RK (2011). Characterisation and transesterification Iranian bitter almond oil for biodiesel production. Appl. Energy 88(7):23-77.

Vasudevan TP, Briggs M (2008). Biodiesel production – current state of the art and challenges. J. Ind. Microbiol. Biotechnol. 35:421-430.

Raja A, Smart D, Lee R (2011). Biodiesel production from *Jatropha* oil and its characterization. Res. J. Chem. Sci. 1:81-87.

Singh RK, Saroj KP (2009). Characterisation of *Jatropha* oil for preparation of biodiesel. Natl. Prod. Radiance 8(2):127-132.

Xu Y, Hanna M (2009). Synthesis and characterization of hazelnut oil based biodiesel. Ind. Crops Prod. 29:473-479.