IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 2, No. 4
November 2013

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 2, No. 4, November 2013

Research Paper

CHARACTERIZATION OF WHITE SEED *SESAMUM INDICUM* L. OIL FOR BIODIESEL PRODUCTION

Nouadjep Serge Narcisse[1,2]*, Kapseu César[1] and Nso Emmanuel[1]

Corresponding Author:* ***Nouadjep Serge Narcisse* ✉ *sergenouadjep@yahoo.fr*

Renewable energy sources are receiving increasing attention with decreasing oil reserves and increasing environmental consciousness. The present work entitled "*Sesamum indicum L.:* A Potential Source for Production of Biodiesel" fits well within the politics of future prospective source of energy and alternate diesel fuel production. The sesame oil was extracted by means of traditional solvent extraction using ethyl acetate. The oil was then characterized and biodiesel was prepared by transesterification using ethyl alcohol of 95°, with potassium hydroxide (KOH) and concentrated sulphuric acid (H_2SO_4) as alkaline and acid catalysts respectively. Physicochemical analyses of the sesame oil as well as the one of the transesterification product shows improvement in fuel properties of sesame seed oil with a cetane number of 51.4; a heating value of 40.1 MJ/kg; iodine number of 109.11; density of 0.860 and viscosity of 1.23 cSt with respect to ethyl esters of sesame oil against 56.77 cSt; 0.910; 39.92 MJ/kg et 50.13 respectively for viscosity, density, heating value and the cetane number according to sesame oil.

Keywords: Biodiesel, Transesterification, Sesame, Cetane number, Fatty acid, Vegetable oil

INTRODUCTION

Since the rice in price of the fossil fuels following the first oil crisis of years 1970, the interest for new and renewable energy sources didn't stop growing and energy under all its forms of conversion is a must for a sustainable development. More than ever nowadays, the politic of a country is determined by the health of its economy and energy is the fuel of economy for the link between energy preoccupation and the one of poverty reduction is undeniable. Biodiesel has a lot of merits since it comes from a renewable and domestic source, it is non toxic, and biodegradable compared to petrol, a fossil fuel which the limited reserves will soon be exhausted (Bajpai and Tyagi, 2006; Ramos *et al.*, 2009). Biodiesel has a relatively high flash point (150°C) that makes it to be less volatile and reassuring for its transportation compared to conventional diesel and its lubrication properties

[1] Department of process engineering, National School of Agro-Industrial Sciences, University of Ngaoundere, P.O.Box. 455 Ngaoundere, Cameroon.

[2] Faculty of Engineering and Technology, University of Buea, P.O. Box 63 Buea, Cameroon.

are owed to the presence of free fatty acid that reduces frictions and expand the life span of the engine. Besides, the physical and thermodynamic properties are near of those of the petrodiesel. In view of valorization, the objective of this work is to take out the potentialities of *Sesamum indicum* L. as "oleofuel" by physicochemical and thermodynamic characterization of *Sesamum indicum* L. in compared with model oils that are being use in biofuel production as well as physicochemical and thermodynamic characterization of the "*sesamdiesel*" with respect to the existing biodiesel. With the believe that the insertion of this oil in biofuel production could contribute to encourage the intensive production of this plant and to give an increment to the economy of the countries of the sub-region of the Central and Oriental Africa where it grows well.

MATERIALS AND METHODS

Experimental Set-up

The reactor used for experiments was the one described by Singh and Padhi in 2009

Extraction of the Sesamdiesel

The biological material is constituted of seeds of white sesame variety, bought in the market in Ngaoundere (Cameroon). The sesame oil is obtained by solvent extraction with a Soxhlet and ethyl acetate as solvent. 15 g of the sample contained in filter papers is placed in the cylinder of the extractor. This is then set on the solvent container filled of ethyl acetate with the ratio of solvent to sample (v/w) of 10/1 to 20/1.

Synthesis of the ethyl esters (sesamediesel)

Transesterification of the crude oil is performed using ethyl alcohol of 95°, with potassium hydroxide (KOH) and concentrated sulphuric acid (H_2SO_4) as alkaline and acid catalysts respectively. The reaction of transesterification is done under agitation at 72°C with 100% excess of ethylic alcohol corresponding to a molar ratio of 6:1 and a concentration in catalyst of 0.5% (according to the mass of oil). A phial of 250 ml equipped with a reflux condenser is used as reactor. The potassium ethoxide gotten by complete dissolution of KOH tablets in ethanol is added under agitation, to the oil previously heated then the mixture is maintained to 72 °C for 2 h and for 12 h in the case of the acidic catalysis after addition of alcohol – sulphuric acid solution. The raw ethyl esters is separated from the glycerol by simple decantation with a separating funnel then is washed by percolation with distilled water and is recovered by decantation. The ethyl ester is heated to rid it of traces of water and alcohol.

PHYSICOCHEMICAL CHARACTERIZATION

The chemical properties have been determined according to the description made by UICPA in 1979. The calorific power (Pc) is calculated using Equation (1):

$$Pc = 11380 - I_i - (9.15 * I_s) \quad ...(1)$$

where Pc = calorific power (kcal/kg)

I_i = Iodine value

I_s = Saponification value

The cetane value (I_c) is determined by using Equation (2) (Krisnangkura, 1986).

$$I_c = 46.3 + (5458/I_s) - (0.225 * I_i) \quad ...(2)$$

where I_s = saponification value

I_i = iodine value

The determination of the kinematic viscosity is based on the determination of the speed of out-flow of a fluid through a capillary tube. This manipulation consists in determining the coefficient of viscosity of the liquid by the Ostwald viscosimetre.

RESULTS AND DISCUSSION

Yield of the *Sesamum Indicum* Oil Extraction

Positions Yield of extraction varies according to the origin of the sesame seed. The thermal extraction (the Soxhlet) presents a better yield than the one in normal temperature. Our best yield (50.23%) is from roasted seeds. It is lower than the one obtained by Elleuch *et al.* (2007) in Sudan and by Tashiroa *et al*. (1990) but, it is greater than the one observed in 2001 by Alpaslan *et al*. (2001) in Turkey and by Yoshida *et al*. (2007). We also observed that this yield (50.23%) remains near or greater to the one with others oleaginous used for biodiesel production - Palm (40-50%) (Cheyns *et al*. (2004; Moudachirou *et al*., 2004). Litmus (45-50%) (Matallah, 2009); Rape (45%) - *Jatropha curcas* (40 and 50%) (Moudachirou *et al*., 2004). These divergences can be assigned to the fact that some factors as the climate, conditions of storage, the time and the temperature of metal grating and the surface of seeds remaining in contact with the solvent influence the output since the content in water of sesame seeds (5.4%) is close to 5.2% mentioned by Yoshida *et al*. (2007).

Fatty Acid Composition

The main fatty acids in the white variety of Sesame seeds oil are, the oleic acid (46.68) and the linoleic acid (35.92). Followed by the palmitic acid, myristic and stearic acid. In minority we have the

Table 1: Sesame Oil Fatty Acids Profile Compared with Other Oils

Fatty Acids	Sesame	Rape [a]	Palm [a, b]	JatrophaCurcas [c, d]	Litmus [a]
AGS	25.53	8.6	48.1	33.1	20.4
Palmitic	9.28	5.1	41.2	11.3	3-10
Stearic	7.09	1.7	5.8	17.0	1-10
Arachidic	0.66	1.7	0.4	4.7	0.3
Myristic	8.5	0.1	0.7	0.1	0.1
AGMI	46,68	60,1	40,8	45,8	75
Oleic	46.68	60.1	40.8	34.3 – 45.8	22 - 75
AGPI	36.29	31.4	10.5	44.5	63.5
Linoleic	35.92	21.5	10.1	29.0 – 44.2	63
Linolénic	0.37	9.9	0.4	0.3	0.5
Ratio					
AGS/AGMI	0.55	0.14	1.18	0.72	0.3
AGS/AGPI	0.70	0.27	4.58	0.74	0.32
AGMI/AGPI	1.29	1.91	3.89	1.03	1.18

Note: *AGS*= Saturated fatty acid ,*AGMI*= Mono-unsaturated fatty acid,*AGPI*= Poly-unsaturated fatty acid. a = Dubois *et al*., 2008; b = Kapseu, 2009; c = Hirata and Berchmans, 2008; d = Tiwarib *et al*., 2007.

arachidic acid (0.66) and linolenic acid (0.37). These results (Table 1) are in the same order that those raised by Ngassoum *et al*. (1998), who notices in addition that the oil of sesame of the white and composite varieties of Cameroon has a strong content in oleic acid compared to the content in linoleic acid whereas the inverse is observed with the colored varieties. These results corroborate those of El Tinay *et al*. (1976); who did a survey on fatty acids of the oils of sesame in Sudan. It is also evident from Table 1 that: the oils of litmus, Jatropha and rape that is mainly rich in oleic and linoleic acids has the same profile as sesame oil. It justifies the adherence of this last to the LA+AGMI (linoleic acidic and mono-insaturated fatty acids) subgroup (Dubois *et al*., 2008), although sesame oil also comes closer to palm oil by its profile in minority compound.

Conversion Ratio

A yield of conversion of 74% (oil to esters) is raised while using a molar ratio alcohol/oil of 6:1 with a basic catalyst (KOH) after two hours of reaction against 60.17% after twelve hours of reaction with the sulphuric acid as catalyst at 72 °C. These rates of conversion are important but remain less than 97% obtained by: Graille *et al*. (1985) and quoted by (Haïdara, 1996) who did the reaction with palm oil, ethanol and 4% of sulphuric acid during 10 h. These rates are also less than 95% obtained by (Korus *et al*. 1984) with litmus oil while using 30% of sulphuric acid in methanol during 5 h. This difference gives us to say with Ma and Hanna, (1999); Meher *et al*. (2006) that transesterification in alkaline environment is faster and requires less catalyst than the one in acidic environment. Also raise that at the beginning (30 to 60 min) of the separation phase the biodiesel is opaque and becomes with time clear and practically transparent. It gives to think that the reaction of transesterification was again in progress and that the more the time of separation is long, will be better the separation and the yield of conversion.

Physicochemical and Thermodynamic Properties

After transesterification one observes a drop of saponification and iodine values from the sesame oil to the "*Sesamdiesel*" of 188 to 184.02 and 112 to 109.11, respectively. It can be due to the opening of some double bonds during the reaction of transesterification under the effect of alcohol and the temperature. The iodine value (109.11) gotten is lower to the maximum value admitted by the guideline EN 14214 of the European norm for biodiesels. The physical properties of vegetable oils are generally close with those of diesel oil; it is this fact that imposed vegetable oils as fuels of substitution to the diesel oil in the diesel engines. The viscosity and density are parameters that intervene in the mechanism of rupture and pulverization of jet of fuel way out the injector into the combustion chamber and thus make part of properties of use and classification of fuels. The cetane value is one of the most important features of a gasoil. It globally expresses the ability of a diesel combustible to ignite in the combustion chamber of a diesel engine. It has some direct impacts on the skill of starting in cold weather (Meher *et al*., 2006), the stalling of the combustion cycle, the pressure gradient, the maximum pressure, and the noise. The cetane value of vegetable oils is generally lower than the one of normal diesel oil. It represents the quantity of heat given up by fuel by unit of mass. Table 2 illustrates the physical and thermodynamic properties of the "*Sesamdiesel*". The viscosity (1.23) and the density (0.860) of sesame ethyl esters are lower to those gotten for *Jatropha curcas* ethyl esters by Mittelbach *et al*. (1999).

Table 2: *Sesamdiesel* Physicochemical and Thermodynamic Properties Compared with Other Biodiesel and American and European Specifications for Biodiesels

Properties	Biodiesel from litmus oil	Biodiesel from JatrophaCurcas oil	Biodiesel from palm oil	*Sesame diesel*	Gazole	ASTM Norm	EN Norm
Viscosity (mm^2\s)	4.5	5.54	–1.23	(40 °C)	7	1.9-6 (40°C)	3.5-5 (40°C)
Density	0.88	0.88	–	0.860	0.83-0.86	–	0.86-0.9
Cetane value	49	59	62	51.41	45 - 52	<47	<51
Calorific Power (Mj/kg)	33.5	39.6	33.5-35.6	40.1	35.3-36.3	–	–

These values are also lower to those gotten by Humke and Barsic (1981) for a mixture at 25% of litmus oil with diesel oil. Nevertheless it is to observe that the gotten values are in conformity with those specified by the European and American standards.

According to the observed differences, one can understand that the viscosity (the probably biggest difference between vegetable oils and the diesel oil) increases with the degree of saturation of oil and say with Bruwer *et al*. (1980) that vegetable oils should be 30 times more viscous than diesel fuel. The calorific power (40.1) is greater than the one obtained by Kulkarni *et al*. (2007); De Theux (2004); Srivastava and Prasad (2004) for the methyl esters from: rape oils, palm, Jatropha and of litmus. The "*Sesamdiesel*" cetane value (51.41) is greater than the one of the biodiesel from litmus oil (Srivastava and Prasad, 2004) and it is close to the one of the biodiesel obtain from rape oil and is lower than one of the ethylic esters from *Jatropha curcas* oil (Mittelbach *et al*., 1999) and of palm oil (Srivastava and Prasad, 2004). This cetane value is however greater than the minimum value admitted by the EN14214 and ASTM-D6751 instructions that are respectively 51 and 47.

One also notes that cetane value of the "*sesamdiesel*" is greater than the one of the conventional diesel and this could be dependent of several parameters notably, the variety, the climatic conditions, storages conditions of oils and also of seeds of which they are obtained and also the technology of production of these oils. One can also notice that the more the chain of fatty acid is long and saturated, the more the cetane value is high (Bajpai and Tyagi, 2006; Ramos *et al*., 2009; Knothe *et al*., 1998; Knothe *et al*., 2003; Dermibas, 2005).

CONCLUSION

The objective of this work was to highlight the potential of the oilseed *Sesamum indicum* to be considered as a source of alternative fuel to conventional diesel oil. With extraction yield of 50.23%, the conversion rate into ethyl esters using acid catalyst is in the range of 60.17 % and 74 % using alkaline catalyst. Moreover, sesame oil, as well as the ethyl ester obtained from the transesterification complies with the requirements of European and American standards relating to the biodiesel oils and crude oils that can be used in its production. In view of the foregoing, we can say that the oilseed *Sesamum indicum* would be "biodieseligenic" and this is an argument for better value as a source of foreign exchange and encouragement in the sense of extensive cultivation.

REFERENCES

1. Alpaslan M, Boydak E, Hayta M, Gerçek S and Simsek M (2001), "Effect of Row Space and Irrigation on Seed Composition of Turkish Sesame (*Sesamum indicum* L.)", *Journal of the American Oil Chemists' Society*, Vol. 78, No. 9, pp. 3.
2. Bajpai D and Tyagi V K (2006), "Biodiesel: source, production, composition, properties and its benefits", *Journal of Oleo Science*, Vol. 55, No. 10, pp. 487–502.
3. BruwerJ J, Boshoff B V D, Hugo F J C, Fuls J, Hawkins C, Walt A, Engelbrecht, and DuplessisL M (1980), "The utilization of sunflower seed oil as a renewable fuel for diesel engines", *American Society of Agricultural Engineers, Vol.* 2, No. 4, p. 81.
4. Cheyns E, Akindès F and Kouamé Y S (2004), "Le palmier à huile en Côte d'Ivoire : deux logiques pour une filière entre normalisation et diversité des produits". In: *Fruits des terroirs, fruits défendus. Identités, mémoires, territoires*, B. Charlery de la Masselière éd., Toulouse, France, Presses universitaires du Mirail, pp. 197-213.
5. De Theux B (2004), "Utilisation de l'huile de palme comme combustible dans les moteurs diesel", *Travail de fin d'études en vue de l'obtention du diplômed'Ingénieur industriel.Section Electromécanique,Institut Supérieur Industriel, Haute Ecole LEONARD de VINCI*.
6. Dermibas A (2005), "Biodiesel production from vegetable oils via catalytic and noncatalytic supercritical methanol transesterification methods", *Progress in Energy and Combustion Science*, Vol. 31, Nos. 5-6, pp. 466–487.
7. Dubois V, Breton S, Linder M, Fanni J and Parmentier M (2008), "Proposition de classement des sources végétales d'acides gras en fonction de leur profil nutritionnel", *Oléagineux Corps gras et Lipides,* Vol. 15, No. 1, pp. 56-75.
8. El Tinay A H, Khattab A H and Khidir M O (1976), "Protein and oil compositions of sesame seed", *Journal of the American Oil Chemists' Society*, Vol. 53, No. 10, pp. 648-653.
9. Elleuch M, Besbes S, Roiseux O, Blecker C and Attiah (2007), "Quality characteristics of sesame seeds and by-products", *Journal of Food Chemistry*, Vol. 103, No. 2, p. 10.
10. Haïdara A O (1984), "Valorisation d'une huile végétale tropicale : l'huile de pourghère", *Mémoire de maîtrise es. Sciences appliquées, Université de Sherbrooke (Quebec)* Canada.
11. Hirata S and Berchmans H J(2008), "Biodiesel production from crude *Jatrophacurcas* L. seed oil with a high content of free fatty acids", *Bioresource Technology*, Vol. 99, No. 6, pp. 1716-1721.
12. Humke A L and Barsic N J (1981), "Performance and Emissions Characteristics of a Naturally Aspirated Diesel Engine with vegetable oils", *Society of Automative Engineers*, No. 810955.
13. Kapseu C (2009), "Production, analyse et applications des huiles végétales en Afrique", *Oléagineux Corps gras et Lipides*, Vol. 16, No. 4, pp. 215-229.

14. Knothe G, Bagby M O and Ryan III T W (1998), “Precombustion of fatty acids and esters of biodiesel. A possible explanation for differing cetane numbers”, *Journal of the American Oil Chemists’* Society, Vol. 75, No. 8, pp. 1007–1013.

15. Knothe G, Matheaus A C and Ryan III T W (2003), “Cetane numbers of branched and straight chain fatty esters determined in an ignition quality tester”, *Fuel* , Vol. 82, No. 8, pp. 971–975.

16. Korus A R, Dwight SH, Noradra B, Charles L P and Drown D C (1984), “Transestérification process to manufacture ethyl ester ofrape oil”, *Department of Chernicalengineering*, *University of Idaho*,pp. 815-826.

17. Krisnangkura K (1986), “A simple method for estimation of cetane index of vegetable oil methyl esters”, *Journal of the American Oil Chemists’ Society*, Vol. 63, No 4, p. 552.

18. Kulkarni M G, Dalai A K and Bakhshi N N (2007), “Transesterification of canola oil in mixed methanol/ethanol system and use of esters as lubricity additive”, *Bioresource Technology*, Vol. 98, No. 10, pp. 2027-2033.

19. Ma F and Hanna M A (1999), “Biodiesel production: a review”, *Bioresource Technology*, Vol. 70, No. 1, pp. 1–15.

20. Matallah M A A (2009), “Marché Mondial des Oléagineux”, Institut National Agronomique (INA) Alger – Magistère.

21. Meher LC, Vidya S D andNaik S N (2006), “Technical aspects of biodiesel production by transesterification”, *Renewable and Sustainable Energy Reviews*, Vol. 10, No. 3, pp. 248-268.

22. Mittelbach M, Giibitz G M and Trabi M (1999), “Exploitation of the tropical oil seed plant *Jatrophacurcas L.*”, *Bioresource Technology*, Vol. 67, No. 1, pp. 73-82.

23. Moudachirou M, Kpoviessi DS S, Accrombessi G C, Kossouoh C and Soumanou M M (2004), “Propriétés physico-chimiques et composition de l’huile non conventionnelle de pourghère (*Jatrophacurcas*) de différentes régions du Bénin”,*Compte Rendu Chimie*, Vol. 7, No. 10, pp. 6.

24. Ngassoum M B, Tenin D, Kayem G J, Lena L, Arto J and Duprat F(1998), “Distribution des stérols et des acides gras de sésames de différentes variétés cultivées au Cameroun”, 2eSéminaire international sur la valorisation du safoutier et autres oléagineux non-conventionnels, Presse Universitaires d’Afrique, Yaoundé, pp. 175-183.

25. Ramos M J, Fernández C M, Casas A, Rodríguez L and Pérez Á (2009), “Influence of fatty acid composition of raw materials on biodiesel properties”, *Bioresource Technology* , Vol. 100, No. 1, pp. 261–268.

26. Singh R K and PadhiK Saroj (2009), “Characterization of jatropha oil for the preparation of biodiesel”, *Natural Product Radiance*, Vol. 8, No. 8, pp. 127-132.

27. Srivastava A and Prasad R (2000), “Triglycerides-based diesel fuels”, *Renewable and Sustainable Energy Reviews*, Vol. 4, No. 2, pp. 111–133.

28. Tashiroa T, Fukudab Y, Osawaa T and Namikia M (1990),”Oil and Minor Components of Sesame *(Sesamum indicum* L.) Strains”, *Journal of the*

American Oil Chemists' Society, Vol. 67, No. 8, pp. 508.

29. Tiwarib A K, Kumar A, and Raheman H (2007), "Biodiesel production from jatropha oil (*Jatrophacurcas*) with high free fatty acids: An optimized process", *Biomass Bioenergy*, Vol. 31, No. 8, pp. 569–575.

30. UICPA (1979), "Méthodes d'analyses des matières grasses et dérivés", 6 Edition. Lavoisier TEC et Doc, Paris (France), pp. 190.

31. Yoshida H, Tanaka M, Tomiyama Y and Mizushina Y (2007), "Regional distribution in the fatty acids oftriacylglycerols and phospholipids of sesameseeds (*sesamum indicum*)", *Journal of Food Lipids*, Vol. 14, No. 2, pp. 189–201.

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com

ISSN 2319-5991