BIODIESEL STARTING FROM NON EDIBLE OILS AND ETHANOL FOR SELF-CONSUMPTION IN THE AGRO INDUSTRIAL PRODUCTION OF SUGAR AND OTHER FOODS

By

MARLEN C. ALFONSO LORENZO[1], RINALDO CARO SANABRIA[1], MILAGROS DUARTE VASALLO[1],MANUEL DÍAZ DE LOS RÍOS[2], INDIRA PÉREZ[2], RAMÓN PILOTO[3], NAYVI FERRER[3], NOEL FERRER[3] and ANTONIO VERA MÉNDEZ[4]

[1]ICINAZ) (Cuban of Sugar Research Institute)
[2]ICIDCA (Cuban Institute for Researching of Sugar Cane By-Products)
[3]CETER (Center of Studies of the Technologies of Renewable Energy)
[4]NICA (National Institute of Sugar Cane Research)
marlen.alfonso@icinaz.minaz.cu

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Abstract

THE DECREASE of fossil fuels in the near future and climate change constitute the main drivers at the present time for the development of biofuels. They are doubly relevant to the sugar industry because it is a consumer of fuels as well as a potential producer. This paper shows the results of an experimental preliminary study with oleaginous plants, which can be cultivated in soils unsuitable for the production of food, with high yields of around 1 t/ha. Experiences of the synthesis of fuel from such oil and ethanol are reported, which turn out to be somewhat complex but allow the production of biodiesel starting from totally renewable sources with important environmental advantages. An example is shown in which it is possible to achieve biodiesel production to substitute for the consumption of all agricultural diesel by using a small percentage of the land belonging to a farm complex for the production of sugar and other foods. Results for the use in cane transport, at mixtures of 5, 10, 20, 50 and 100% (total substitution) of biodiesel are also presented.

Introduction

According to experts, petroleum prices will tend to increase (US. Department of Energy. September 2008; US Senate, 2005; Benjamin, 2007). It could be strategically important for the agro-industrial production sector (for example, sugar production) to introduce new energy alternatives using renewable sources, as in the case of biodiesel that uses raw materials such as oils of vegetable origin that can be obtained every year and of ethanol that also comes from a renewable source.

We have designed a small plant for biodiesel production using the oil of *Jatropha curca* or *Ricinus communis* as the source of fatty acids. They are oleaginous plants producing non-edible oils and are adapted well to soils which are not fit for food production.

Consequently, there is no competition for the use of soils where foods can be produced.

The biodiesel to be produced would allow the substitution of the diesel fuel that is currently used as the main energy source in the production of foods including sugarcane.

The proposal is to install the biodiesel production plant in a strictly agricultural production farm or in an agro-industrial complex with the purpose of substituting in a partial or total way the consumption of diesel fuel either partially or totally.

The process of biodiesel production is already common in the world, mainly using edible oils whose production in commercial plantations is much more extensive, for example, soy or sunflower oils. In almost all the processes, methanol is used that allows a quicker synthesis process and, in many cases, with slightly higher yields. Methanol has a higher price than ethanol, and the latter allows the production of biodiesel starting from completely renewable sources and it has less effect on the environment and, for these reasons, ethanol was selected for use in the process of this plant.

The complexities for the synthesis from ethanol have already been solved in the ICINAZ up to and including the pilot plant scale. Biodiesel could be employed in mixtures substituting 10, 20, 50% of the diesel fuel, even up to B100 (100% biodiesel) provided that it fulfils the quality specifications of the existing standards.

Results of the simulation of a plant for the production of biodiesel with the software Super Pro Designer version 3.04

With the designed plant, a study was conducted to enlarge the capacity until arriving at one acceptable time of recovery. The results of this study of sensitivity appear in Table1.

Table 1—Analysis of the plant capacity influence upon the time of investment return.

Capacity (t/year)	Time of investment return (years)
64	6.54
160.3	4.43
320	2.70

Increasing production capacity of one alternative to another, it also increased the capacity of the equipment and the tanks, as well as their costs.

The simulation included a non-complex technology, without glycerine purification nor recovery of the solvent used, and this gave a minimum capacity of 320 t per year of biodiesel for the given costs of the raw materials, selling price of the biodiesel (similar to diesel fuel), cost of labour, cost of equipment, etc. The calculated capacity is similar to the planned diesel fuel expenditures of the 'Honduras' agricultural enterprise to which this farm belongs. Any variation in the values of some of these variables has an influence on the time of the return of the investment. This can be shown in the sensitivity analysis carried out in the 160.3 t/y plant when the price of alcohol diminishes (Pérez, 2006) (Table 2).

Table 2—Analysis of the influence of the alcohol price on the time of return of the investment in the plant of 160.3 tonnes/year.

Price of the alcohol (cents/L)	Time of return of the investment (years)
0.56	4.43
0.44	3.76

Study of the behaviour of a Yuchai motor with different biodiesel proportions in the diesel mixture (Alfonso, 2008).

Tests were conducted in the engine testing setup of the CETER, for which standard samples of diesel fuel and mixtures of this with biodiesel in different compositions were used. Measurements were conducted for the following parameters – Effective Power (Ne), Torque (Me), Hourly fuel consumption (Gc) and Specific Consumption (gc) – against frequency of revolution (r/min) when the fuel control valve is completely open, that is, when the maximum dosage of fuel is achieved (Table 3). This parameter gives useful information when giving the maximum parameters

of power and torque with their minimum specific consumption and the revolutions at which these are obtained.

Table 3—Technical specifications of the YUCHAI motor (which is used in the trucks hauling sugarcane).

Item	Specification
Model.	YC61108Q
Type.	Vertical, on-line, four cycles, water cooling
Combustion camera.	Direct injection
Number of cylinders.	6
Diameter of the cylinder. (mm)	108
Piston stroke. (mm)	125
Compression ratio.	16.5:1
Nominal power. (KW)	112
Nominal revolution. (r/min.)	2800
Torque maximum. (Nm)	428
Revolutions at maximum torque. (rpm.)	1600–1900
Minimum fuel consumption at full load (kg/h)	224.4
Proportion of consumption of fuel and of oil. (%)	0.8
Temperature of escape gases. (°C)	650
Number of escape smoke. (Bosch)	4.0
Mean piston speed. (m/s)	11.7

Test results

With the study of the combustion of the biodiesel in a motor and with the parameters of operation of the diesel, it was possible to reach the following conclusions:

- When the biodiesel content increases above 20%, the characteristics of the motor diminish slightly and a slight increase of the specific consumption of fuel was observed.
- The emissions of NOx diminish markedly as the biodiesel content is increased, which could be due to the decrease in the temperature in the combustion chamber as the content of biodiesel increases.
- The appropriate mixture for use in this Motor of Internal Combustion is B20, that is to say 20% biodiesel, because with this you achieve a compromise between the emissions and the benefits of the motor.

It is important to point out that these results were obtained without physical or operational modification to the motor. Even better behaviour for the biodiesel and the mixtures should be expected by correcting the angle of injection of the motor.

Preliminary results of the agricultural parameters in the 'Paraguay' farm

The study of the behaviour of *Ricinus communis* in the soils of category N of the 'Paraguay' farm began in the year 2007 with two species coming from the farm denominated red and green.

Later on, the Imias species labelled white was incorporated in the year 2008. In the year 2008, the study of the *Jatropha curcas*, variety of Cape Verde, coming from the bank of germplasm of *CATEDES* also began (Center of the CITMA, located in Guantánamo province)(Table 4).

Table 4—Yield behaviour during 2008 and 2009.

Oleaginous species	Planting frame	Year of crop	Yield in fruits (kg/ha)	Yield in oil (kg/ha)
Ricinus (green species)	2.4*2.4	2008	881.2	294
Ricinus (red species)	2.4*2.4	2008	1249	416.3
Ricinus (green species)	2.4*2.4	2009	406.2	135.4
Ricinus (red species)	2.4*2.4	2009	1187.5	400
Ricinus (species of Imias)	3*3	2009	780	260
Jatropha curcas (Green End)	4*3	2009	94.3	31

The experimental areas had been subjected to an extreme drought for 6 months. However, a suitable yield was obtained particularly in the case of the *Ricinus* red species coming from the same 'Paraguay' farm.

Food security requires two fundamental aspects:

- Availability of fuel sources for the production of foods (quantity and prices).
- No use of foods for energy production

This compromising situation can be avoided if such premises are applied as:

- Using oleaginous plants for biodiesel. These are not used for the production of food or other uses such as microalgae fermentation in residual waters.
- The use of oleaginous plants that can be planted in degraded soils not fit for food production (*Jatropha curcas* and *Ricinus communis*) as the present study shows.
- Stimulate the local production of biodiesel with the purpose of substituting it in agricultural machinery, pumping stations, electrical power-plants, etc.

Conclusions

Positive results were obtained in biodiesel production with ethanol, at the pilot plant level. The use of the produced biodiesel and their mixtures with diesel in motors of trucks hauling sugarcane were good in spite of not making any modifications to the motor. -Preliminary and encouraging results exist in the exploitation of experimental areas of so called N soils with *Jatropha* and *Ricinus.*

Recommendations

- To continue the studies in the 'Paraguay' farm and in other edapho-climatic areas of the different species of oleaginous plants of non-edible oils.
- To continue studies in the use of biodiesel in the main types of diesel motors used for agricultural purposes.
- To continue studying the synthesis of ethyl esters using as starting materials the raw oils of *Jatropha* and *Ricinus*.

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LE BIODIÉSEL À PARTIR D'HUILES NON COMESTIBLES ET D'ÉTHANOL POUR LA CONSOMMATION INTERNE DANS LA PRODUCTION AGRO INDUSTRIELLE DE SUCRE ET D'AUTRES DENRÉES ALIMENTAIRES

Par

MARLEN C. ALFONSO LORENZO[1], RINALDO CARO SANABRIA[1], MILAGROS DUARTE VASALLO[1],MANUEL DÍAZ DE LOS RÍOS[2], INDIRA PÉREZ[2], RAMÓN PILOTO[3], NAYVI FERRER[3], NOEL FERRER[3] et ANTONIO VERA MÉNDEZ[4]

[1]ICINAZ) (Cuban of Sugar Research Institute)
[2]ICIDCA (Cuban Institute for Researching of Sugar Cane By-Products)
[3]CETER (Center of Studies of the Technologies of Renewable Energy)
[4]NICA (National Institute of Sugar Cane research)
marlen.alfonso@icinaz.minaz.cu

MOTS-CLÉS: Énergies Renouvelables, Énergie, Biodiesel, Éthanol, Biocarburants.

Résumé

LA DIMINUTION de combustibles fossiles dans un avenir proche et les changements climatiques constituent les principales motivations à l'heure actuelle pour le développement des biocarburants. Elles sont doublement pertinentes à l'industrie sucrière car elle est consommatrice d'énergie aussi bien que producteur potentiel. Cette communication présente les résultats d'une étude préliminaire expérimentale avec des plantes oléagineuses produisant des huiles non comestibles telles que le *Jatropha curcas* et *Ricinus communis*, qui peuvent être cultivées dans les sols impropres à la production de denrées alimentaires, avec des rendements élévés d'environ 1 t/ha. Des expérimentations de la synthèse de telles huiles et de bioethanol sont rapportées. Elles se sont avérées quelque peu complexes mais ont permis la production de biodiesel à partir de sources totalement renouvelables avec les avantages environnementaux consequents. A titre d'exemple il est démontré qu'il est possible de produire suffisamment de biodiesel équivalent à la consommation totale de diesel agricole à l'aide d'un faible pourcentage des terres appartenant à une ferme orientée vers la production de sucre et d'autres aliments. Des résultats pour l'utilisation dans le transport de la canne à sucre, à des mélanges de 5, 10, 20, 50 et 100% (substitution totale) de biodiesel sont également présentés.

BIODIESEL A PARTIR DE ACEITES NO COMESTIBLES Y ETANOL PARA EL AUTOCONSUMO EN LA PRODUCCIÓN AGROINDUSTRIAL DE AZÚCAR Y OTROS ALIMENTOS

Por

MARLEN C. ALFONSO LORENZO[1], RINALDO CARO SANABRIA[1], MILAGROS DUARTE VASALLO[1],MANUEL DÍAZ DE LOS RÍOS[2], INDIRA PÉREZ[2], RAMÓN PILOTO[3], NAYVI FERRER[3], NOEL FERRER[3] y ANTONIO VERA MÉNDEZ[4]

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[4]*NICA (National Institute of Sugar Cane Research)*
marlen.alfonso@icinaz.minaz.cu

PALABRAS CLAVE: Renovable, Energía, Biodiesel, Etanol, Biocombuatibles.

Resumen

EL DECRECIMIENTO de los combustibles fósiles en el futuro cercano y el cambio climático constituyen los principales impulsores actuales para el desarrollo de biocombustibles. Éstos son doblemente relevantes a la industria azucarera porque es una consumidora de combustibles, así como una potencial productora. El artículo presenta los resultados de un estudio experimental preliminar con plantas oleaginosas productoras de aceites no comestibles como la *Jatropha curca* y *Ricinos communis* , que pueden ser cultivadas, con altos rendimientos de cerca de 1 t/ha, en suelos no aptos para la producción de alimentos. Se reportan experiencias de la síntesis del combustible a partir de estos aceites y etanol., que resultan ser algo complejas , pero permiten la producción de biodiesel a partir de recursos totalmente renovables con importantes ventajas ambientales. Se muestra un ejemplo en el que es posible alcanzar una producción de biodiesel para sustituir la totalidad del consumo agrícola de diesel , con el uso de un pequeño 5 de tierras que pertenecen a un complejo agrícola dedicado a la producción de azúcar y otros alimentos. Se presentan también resultados de su uso en el transporte de caña, en mezclas de 5, 10, 20, 50, y 100% (sustitución total) de biodiesel.