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Assessment of the feasibility of different oil sources to biodiesel production

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ABSTRACT. The use of Biodiesel allows several advantages over diesel fuels such as lower pollutants emission profiles into the atmosphere, hand jobs posts creating, and reduction of imported diesel fuel. Since the program has begun, the soybean oil has been used as mainly raw material to biodiesel production. In fact, this culture is the only that can afford the production needs from biodiesel facilities. However, this oil is a commodity and alternatives fatty materials sources have to be found in order to increase the competitiveness of the process and release the oilseed production to food industry. This work has focused on evaluating the potential use of castor oil, ouricuri, babassu, castanets, macauba and seeds of passion fruit and pinecone as alternative sources to biodiesel production. The results have shown that the evaluation of moisture content of the samples plays an important role before oil content determination and except the seeds of passion fruit, all of them shown oil potential to supply biodiesel production needs.

Keywords: biodiesel, feedstock, oilseeds, vegetable oil.

Determinação do teor de umidade e lipídios de diferentes oleaginosas típicas do nordeste brasileiro para a produção de biodiesel

RESUMO. O biodiesel apresenta vantagens como menor emissão de poluentes na atmosfera, geração de empregos, além de diminuir a importação de óleo diesel. Desde o início do programa a soja tem sido a matéria-prima por excelência da produção nacional de biodiesel, porque este agronegócio é o único com escala para atender a demanda das usinas. No entanto, materiais graxos alternativos devem ser buscados para aumentar a competitividade do processo e desvincular a produção de uma fonte oleaginosa alimentar. O objetivo do presente trabalho foi o estudo da potencialidade da utilização de óleo de mamona, ouricuri, babaçu, castanhola, macaúba e sementes de maracujá e pinha, para a produção de biodiesel. Os resultados demonstraram que a determinação da umidade das amostras foi fundamental antes de se medir o teor de óleo, além disso, com exceção das sementes de maracujá, todas as demais oleaginosas se apresentaram com potencial para a produção de biodiesel.

Palavras-chave: biodiesel, matéria-prima, oleaginosas, óleo vegetal.

Introduction

The National Program for Biodiesel Production and Use (PNPB) was officially launched in 2004 and implemented in 2008, when all diesel sold on national territory should contain 2% biodiesel mixed with petroleum diesel (B2). This mixture underwent gradual increases: to B3 in March 2008, B4 in July 2009, and B5, since January 1st, 2010 (ANP, 2010).

By definition, biodiesel is a natural substitute of petroleum diesel, and can be produced from the alcoholysis of vegetable oils/animal fats or through the esterification of grease raw materials with high acidity, employing short-chain alcohols in the presence of a catalyst, which can be homogeneous, heterogeneous or enzymatic (CORDEIRO et al., 2008; KUCEK et al., 2007, SILVA et al., 2011).

In general, alkyl esters of fatty acids can be produced from any kind of vegetable oil, but some of them are not suitable as feedstock for biodiesel production. Therefore, when proposing an oilseed source, three aspects should be respected: (i) the technical and economic viability for agricultural production of oilseeds, (ii) the technical and economic feasibility for the extraction of oil and process it into biodiesel, and (iii) ensuring that the amount of produced biofuel will be compatible with its use in vehicle or stationary engines. If one of these three aspects is not adequately met, the source of oilseed in question should not be considered suitable for the biodiesel production (SUAREZ et al., 2009).

Since the beginning of PNPB, the Brazilian government, through the social fuel seal, offers tax incentives for biodiesel plants, depending on two factors: (1) its location within the national territory, and (2) the use of raw materials from familiar agriculture (ANP, 2010; SCHNEIDER et al., 2011).

Currently, Brazil is the fourth largest producer of biodiesel, just behind Germany, United States and France, the first, second and third places, respectively. Soybeans have been the main raw material used since the beginning of PNPB, and its oil was used in 2009 and from January to August 2010 at 77.90% of national production, against the employment of 16.15% tallow, 3.50% cottonseed oil, and other feedstocks with only 2.45% (ANP, 2010).

The soybean crop has sustained the national production of biodiesel due to the fact of this important agribusiness is currently the only one to present the scale needed to meet the required goals of (B5) use. However, once this oil is a commodity, alternative fatty materials should be sought to increase the profit margin of the process and to unlink the biodiesel production from an oilseed food source (RAMOS et al., 2011).

The present work studied the potential and feasibility of using different oil crops such as castor oil plants, ouricuri, babassu, castanets, macauba and seeds of passion fruit and pinecone, for the feedstock supply for the biodiesel production.

Material and methods

We collected and quantified the content of oil and moisture of samples of castor oil plants, ouricuri, babassu, castanets, macauba, and passion fruit and pinecone from different regions of Alagoas State, Brazil. For comparison with the results obtained for the wild castor oil plants, we used a kind of castor oil plant developed by Brazilian Enterprise for Agricultural Research (EMBRAPA) (castor oil plant Paraguaçu, BRS 188, Garanhuns, Pernambuco State, Brazil).

The determination of oil content was performed by soxhlet, through the extraction of fatty materials heated with ethanol or hexane. The plant samples were ground, weighed and dried at 60°C for 24h and weighed again. The plant material (pulp or almonds) without humidity were then individually wrapped in packs of filter paper and packed in soxhlet.

After the extraction (72h), the solution (oil/solvent) was filtered and evaporated at reduced pressure. To eliminate any residual solvent, the oil obtained was heated in an oven at 40°C for 24h.

The determination of the amount of oil in the kernel and in the pulp of the oilseed was based on weighing the extraction cartridges. Before each extraction the cartridges with the samples were weighed, and after extraction they were weighed again, after drying in an oven until constant weight. The difference between the first and second weighing provided the missing mass, and the oil content calculated by the following equation:

$$Oil\ Content = \frac{Mci - Mcf}{Msi} x100\,\%$$

where:

Mci is the initial mass of the cartridge; Mcf is the final mass of the cartridge, and Msi is the initial mass of the sample.

Drying of the samples was carried out in Infrared moisture analyzer IV2000 (Gehaka®), where the sample is dried at a fixed temperature until the weight variation, determined at each interval of 30s, is lower than a set value (%).

Results and discussion

At the beginning of the Brazilian biodiesel program, the castor oil plant received great attention by its adaptation to regions with low rainfall, such as Brazilian semi-arid, thus enabling social inclusion through family agriculture. However, the esters produced from this oil have kinematic viscosities (~14 $mm^2\ s^{-1}$) above the limits established by the specifications of the engines, which does not allow direct use, since, owing to its higher viscosity, the fuel is not efficiently atomized inside the combustion chamber, resulting in the accumulation of fuel in filters and injection systems and, thus impairing the performance and engine life. For this reason, the biodiesel castor oil needs to be blended with diesel oil or other low-viscosity ester to have any practical application. Moreover, its market value is high due to its wide use by castor oil industry (RAMOS et al., 2011).

Recently it has been developed by the U.S. company Amyris, a technology for the production of hydrocarbons with similar structure to diesel oil (green diesel), a process very similar to the ethanol production, which uses yeast to ferment the sugars in the cane and secrete ethanol (AMYRIS, 2010). The difference is in the yeast DNA, which has been genetically modified to secrete hydrocarbons rather than ethyl alcohol. However, this new fuel does not have the benefit of the lubricity of biodiesel, and the esters of castor oil can be used as alternative additives to correct viscosity.

Initially samples were taken from seeds of castor oil plant Paraguaçu (BRS 188), with the extraction of oil being carried out with anhydrous ethyl alcohol and hexane (Table 1).

Table 1. Content of oil/moisture of castor oil plant Paraguaçu (BRS 188).

Sample	Moisture (%)	Oil Content (%)	
		Ethanol	Hexane
1	5.4	47.0	43.0
2	5.4	48.0	39.0
Average	5.4	47.5	41.0

Ethanol showed a better performance in the extraction, due to the fact that the major component of castor oil is ricinoleic acid, which has a hydroxyl at its carbon 12, which increases its solubility in alcohols (GUSTONE, 2004).

One of the key parameters in determining the oil content refers to the moisture, and according to Azevedo and Beltrão (2007) the first step in quantifying the existing oil in the seeds is the removal of the moisture from the seeds and pulp surrounding the kernel.

The determination of oil content has been expanded to wild castor oil plants seeds from 10 cities of Alagoas State, Brazil (species with no control in their cultivation, Table 2).

Table 2. Content of oil and moisture of the wild varieties of castor oil plants.

Locality	Moisture (%)	Oil Content (%)
Messias	4.8	42.1
Marechal	4.8	45.2
Chã Preta	4.6	45.9
Cajueiro	4.9	44.5
Pilar	3.3	43.0
Atalaia	6.0	41.1
Paulo Jacinto	4.5	46.3
Rio Largo	4.4	46.0
Capela	4.8	43.4
Viçosa	4.6	42.5

The moisture determination indicated that the samples had, on average, values of 4.7%, pointing out the importance of the drying prior to determination of oil content, since this would cause an error of more than 4% in the measures. Besides, the moisture determination is important to check the appropriate conservation conditions of the plant material, such as temperature and the shelf life prior to degradation by microorganisms. Regarding the average content of oil, as well as moisture, there were very similar values regardless of the variety used, with average levels of 44%. Basically, the difference among the varieties lay on the seed yield per plant.

The oil quantification of the castor plants at different growth stages was also performed, using ethanol as a solvent that showed the best extraction. Extractions were carried out with materials at various growth stages, from its early stage, green, until its final stage, mature.

Fruits from a castor oil tree, Paraguaçu, were collected, with green seeds, intermediate 1, intermediate 2, and mature, for determination of the content of moisture and oil (Table 3, Figures 1 and 2).

Table 3. Content of oil and moisture of the ripening stages of castor oil plant Paraguaçu.

Sample Number	Phases of Maturation	Moisture (%)	Oil Content (%)
1	Green castor oil plant	9.3	37.1
2	Intermediate 1*	8.7	42.3
3	Intermediate 2*	7.4	47.4
4	Mature castor oil plant	6.8	42.8

*The harvest in cultivars with dehiscent fruits should be performed when the fruits begin to open, dropping the seeds on the ground. This openness intensifies when the weather is hot and dry (CARDOSO et al., 2011). The intermediate stage 1 refers to the early stage of fruit ripening (beginning of the shift from green to brown color) while the second stage refers to the final stage of fruit ripening (predominantly brown and beginning of the opening of fruit).

In Figure 1 it is possible to observe that the oil content had increased according to the stage of fruit growth. However, there is a point at which the fruit reaches its maximum oil content and then starts to decrease (point 3).

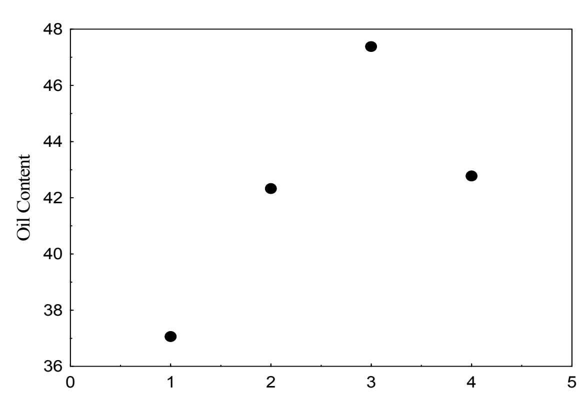

Figure 1. Variation of oil content in relation to fruit ripening of castor oil plant.

Apparently the moisture content decreases with fruit ripening (Figure 2), being inversely proportional to the oil content.

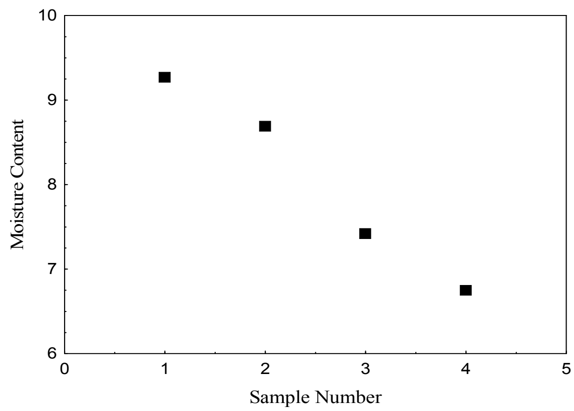

Figure 2. Variation of moisture content in relation to fruit maturation of castor oil plant.

We also determined levels of oil and moisture from other oilseeds: ouricuri, babassu, castanets, macauba, passion fruit and pinecone, using anhydrous ethanol (Table 4).

Table 4. Oil content of the regional oilseeds using ethanol as a solvent.

Sample	Moisture (%)	Oil Content (%)
Ouricuri	4.4	54.0
Babassu	4.6	45.0
Castanets	5.4	35.5
Seeds of passion fruit	5.9	15.0
Macauba	5.5	21.0
Seeds of pinecone	7.8	21.0

The results indicated that macauba and pinecone seeds have oil content similar to soybeans, but with the advantage of being non-food crops. Moreover, the castanet, babassu and ouricuri have presented high oil content, ranging from 35.5 to 54.0% per weight of plant material, being potential suppliers of oil to produce biodiesel. Otherwise, the seeds of passion fruit had the lowest oil content among the plants studied, representing an important raw material for the cosmetic industry and not a good alternative for the production of biodiesel.

Conclusion

The study on the potential of oil supply in all oilseeds had started with the castor oil plants, comparing some physical and chemical properties of the plants from 10 regions of Alagoas State and a sample of castor oil of the Paraguaçu plant. It was observed that the content of oil and moisture had small variations among the samples, even considering geographically distant regions with different cultivars.

Native oilseeds from Alagoas State, such as ouricuri, babassu, castanets, macauba, and seeds of passion fruit and pinecone were also studied. The seeds of babassu and ourucuri were the plants with the highest levels of oil, with 54.0 and 45.0%, respectively. The castanets had a considerable amount of oil, 35%, in addition the macauba and pinecone seeds presented amounts close to the yield of soybeans (21%). On the other hand, the seed of passion fruit had the lowest oil content among the studied species with only 15%.

Aside from passion fruit, all the oils studied are potentially favorable for energy purposes, given their oil content, especially ourucuri, babassu and castanets, which had the highest oil content. The search for sources alternative to soybean oil is essential to the success and continuity of PNPB, mainly to increase the profit margin of the plants already in operation and stimulate new investments in the sector of liquid biofuels from vegetable oils.

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