Estimation on Biodiesel Production Utilizing Contaminated Peanuts in Brazil

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Abstract

Today biofuels are used for their environmental, social and economic benefits. This theoretical study has estimated a potential biodiesel production by utilizing aflatoxin contaminated peanuts (*Arachis hypogaea L.*), which cannot be used for human consumption. About 14.6 million liters of biofuel could be produced if all the contaminated peanuts from the 2016/2017 harvest in Brazil are used as raw materials for biodiesel production. The results of the estimation are based on a transesterification using ethanol as the alcohol and potassium hydroxide as the catalyst. Therefore, two valuable commodities can be produced from contaminated peanuts: biodiesel and glycerin, increasing the agro-industry's profits and reducing residue production without harming food security.

Keywords: Peanut; biodiesel; aflatoxin; residue

Resumo

Hoje em dia, os biocombustíveis são utilizados devido aos seus benefícios ambientais, sociais e econômicos. Este estudo teórico estimou o potencial de produção de biodiesel utilizando amendoins (*Arachis hypogaea L.*) contaminados com aflatoxina, os quais não podem ser usados para consumo humano. Cerca de 14,6 milhões de litros de biocombustível poderiam ser produzidos se todo o amendoim contaminado da safra brasileira de 2016/2017 fosse usado como matéria-prima para produção de biodiesel. Os resultados da estimativa são baseados na transesterificação usando etanol como o álcool e hidróxido de potássio como catalisador. Portanto, duas commodities valiosas poderiam ser produzidas através do amendoim contaminado: biodiesel e glicerina, aumentando os lucros da agroindústria e reduzindo a produção de resíduos, sem afetar a segurança alimentar.
Palavras-chave: Amendoim; biodiesel; aflatoxina; resíduo

Resumen

Hoy en día, los biocombustibles se utilizan por sus beneficios ambientales, sociales y económicos. Este estudio teórico ofrece una estimación de la producción de biodiésel por medio de la utilización de cacahuetes (*Arachis hypogaea L.*) contaminados con aflatoxina, los cuales, no pueden utilizarse para el consumo humano. Cerca de 14,6 millones de litros de biocombustibles podrían producirse si todo el cacahuete contaminado de la cosecha brasileña del 2016/2017 se hubiera usado como materia prima para la producción de biodiésel. Los resultados de esta estimación se basan en el proceso de transesterificación, usando etanol como el alcohol e hidróxido de potasio como catalizador, obteniendo dos productos valiosos: biodiésel y glicerina. Esto podría aumentar los beneficios en la agroindustria y reducir la producción de residuos, sin afectar la seguridad de los alimentos.

Palabras Clave: Cacahuete; biodiésel; aflatoxina; residuo

INTRODUCTION

Biofuels are renewable sources of energy that can be derived from agricultural biomass and organic residues in general. They are more sustainable than fossil fuels, hence they can keep up with the increasing demand for fuels; they generate less greenhouse gas emissions and have the possibility to create more jobs and increase incomes in rural communities in underdeveloped countries (GOLDEMBERG, 2008).

Prodiesel and the Biodiesel Production and Utilization National Program (PNPB) were created in Brazil between 2002 and 2004. PNPB determined that the diesel used in cars and trucks should have 2% of biodiesel in its composition starting at 2008, and this number should increase during the following years. This augmented the Brazilian production and demand of biodiesel significantly. In 2017, the percentage of biodiesel in automotive diesel increased to 8%; thus, there is a need to look for new sources of plant oil (ANP, 2017).

Peanuts have the potential to be used as raw materials for biodiesel because of their high oil content and convenient physical-chemical properties. Even though they can be used for biofuel production, it does not necessarily affect the food market, considering that the residue obtained after the oil extraction (the cake) can be used for human or animal consumption. The cake can also be used as organic fertilizer for plants and can be combusted as biomass. Therefore, peanuts are very versatile and can have different purposes according to its variety and the market prices (BELTRÃO *et al.*, 2009).

The peanut crop is very susceptible to fungus attacks due to inappropriate temperature and humidity control during its whole cycle. The *Aspergillus* fungi can produce aflatoxins, a group of harmful substances that are hepatoxic, carcinogenic, teratogenic and it can even kill the animals that consume the contaminated product (CAMPO/PAS, 2004).

In Brazil, the maximum levels of aflatoxins permitted (types B_1, B_2, G_1 and G_2 combined) in raw peanuts and their products are 20 parts per billion for human consumption (ANVISA, 2002), and 50 parts per billion for animal consumption (MAPA, 1988). In 2015, 2723 samples of peanuts commercialized as food were tested for aflatoxins and 10.7% were above the permitted limit for human consumption (ABICAB, 2015). The contaminated peanuts cannot be used as food due to its toxicity. They cannot even be utilized as a plant fertilizer because of the risks of contaminating the soil and the new crops (CAMPO/PAS, 2004).

The first step of biodiesel production is the oil extraction, which can be done mechanically, utilizing solvents, or both. The mechanical pressing of oilseeds is a feasible solution for small communities of farmers, and its efficiency is related to the seed conditions, such as temperature and humidity (PIGHINELLI, 2007).

Once the oil is extracted, the biodiesel can be obtained by diverse processes, such as transesterification, esterification or thermal cracking. The process of transesterification can occur while utilizing different types of catalysts, such as acids, alkalis, enzymes, or even without any catalysts (supercritical transesterification). In the esterification, the catalysts are usually inorganic acids and the process produces esters and water from a carboxylic acid and alcohol. The thermal process cracking reduces the oil molecules in high temperatures (starting at 350°C), using catalysts to remove the compounds of oxygen (LIMA, 2011).

According to Rodrigues Filho (2010), transesterification is the reaction of a lipid, preferably, with a short-chain monoalcohol, which in the presence of a catalyst results in glycerol and a fatty acid alkyl esters mixture – also known as biodiesel. Today, this process is the most feasible process to produce biodiesel. Even though transesterification is a low complexity chemical reaction, it can still be optimized according to its experimental conditions, such as the molar ratio between triacylglycerides and alcohol, the catalyst concentration and the temperature of the reaction (PIGHINELLI, 2007).

Even though methanol still presents better yield of transesterification and lower production costs, the use of Brazilian sugarcane-made ethanol still presents the following advantages: greater availability, reduction of greenhouse gas emissions, lower toxicity and more jobs created by the industry. Having a sustainable process is of great importance considering that the biodiesel produced from methanol is not a renewable fuel if the alcohol was produced from fossil synthesis gas (PENTEADO, 2005).

According to Oniya and Bamgboye (2014), the transesterification of non-neutralized peanut oil (extracted by mechanical press) utilizing ethanol as the alcohol and potassium hydroxide as a catalyst has a yield of 86.8% (volume) in ethyl esters at the temperature of 60ºC. They also affirm that the biofuel produced had better combustion properties when compared to raw peanut oil.

MATERIAL AND METHODS

According to Christoff (2006), the volume of oil available multiplied by the yield of transesterification is equal to the potential volume of biodiesel. To estimate the potential biodiesel production, utilizing aflatoxin contaminated peanuts, some information was taken from literature as presented on Table 1.

The shell of the peanut pod is not used as raw material for biodiesel, and thus it needs to be discarded for this study. Assuming that 10.7% per shelled peanut harvest is contaminated with aflatoxins that are above the limits for human consumption (ABICAB, 2015), there exists a plethora of seeds that can be used for oil extraction. Peanuts have about 50% of oil content in their seeds (SANTOS *et al.*, 2009). Raw peanut oil has a specific volume of 1.09 L/kg (COSTA & ZAGONEL, 2009). The yield of transesterification utilizing peanut oil, with ethanol as the alcohol and potassium hydroxide (KOH) as the catalyst is 86.8 mL of ethyl esters per 100 mL of peanut oil (ONIYA & BAMGBOYE, 2014). Using this logic, the potential biodiesel production was estimated in the formula below:

$$B = P \times S \times C \times O \times V \times Y$$

B: potential biodiesel production (L)
P: peanut pods (kg)
S: peanut seeds within total mass of the pods (decimal)
C: contamination by aflatoxins (decimal)
O: oil in peanut seeds (decimal)
V: specific volume of the peanut oil (L/kg)
Y: yield of transesterification (decimal)

Table 1. Peanut data found on literature

Peanut data found on literature	Values found
Lowest estimate for the 2016/2017 peanut harvest in Brazil	408,800,000 kg (pods) [1]
Percentage of peanut seeds within total mass	70.5% (by weight) [2]
Peanuts affected by aflatoxins	10.7% [3]
Percentage of oil in peanut seeds	50.0% (by weight) [4]
Specific volume of the peanut oil	1.09 L/kg [5]
Yield of transesterification (peanut oil, ethanol and KOH)	86.8% (by volume) [6]

[1] (CONAB, 2016);
[2] (NAKAGAWA *et al.*, 1993);
[3] (ABICAB, 2015);
[4] (SANTOS *et al.*, 2009)
[5] (COSTA & ZAGONEL, 2009)
[6] (ONIYA & BAMGBOYE, 2014).

RESULTS AND DISCUSSION

According to the data found in literature, and utilizing the formula presented, about 14,588,143 liters of peanut ethyl esters could be produced if the contaminated seeds from the 2016/2017 harvest in Brazil were used as raw materials. Considering the yield of transesterification, this would also produce 2,218,473 liters of crude glycerin as a by-product.

Considering the current (2017) Brazilian regulation on automotive diesel (8% being biodiesel), all the ethyl esters produced from the contaminated peanuts could be added to a total of 167,763,645 liters of fossil diesel.

Assuming that the contaminated peanuts would be wasted; the cost of the biodiesel manufacturing would be lower when compared to other raw materials. Therefore, the peanut agroindustry should consider the option of building biodiesel plants on their properties. The biodiesel produced can be used to run the vehicles at the peanut farms.

CONCLUSIONS

In Brazil, more than 43 thousand metric tons of aflatoxin contaminated peanuts are likely to be distributed for human and animal consumption by the end of the 2016/2017 harvest. If this contaminated material was being used for biofuel production every year, people would have less chances of being intoxicated and developing medical issues in the long term. The farms and factories could be using the biodiesel to run their machines and/or sell it at biofuel auctions. The glycerin produced could be sold at a high price on the market due to its use in the chemical and pharmaceutical industries. Additionally, there would be a decrease in greenhouse gas emissions in contrast with the use of fossil fuels.

The main issue of the peanut biodiesel is that is has a low oxidation stabilization when compared to other fuels. However, this can be fixed easily by utilizing a commercial antioxidant, and thus increasing its shelf life (COSTA & ZAGONEL, 2009).

Notwithstanding, there is a need to inform the government and private companies that there are profitable and sustainable ways to manage agro-industrial waste. Research should focus on developing new techniques to manufacture biofuels, as well as looking for raw materials that have not been used before like residues from industrial processes and other sources that do not affect food security.

The authors of this study also published a more comprehensive study about bioenergy production in Brazil utilizing aflatoxin contaminated peanuts. Using the raw oil, shells and cake as biomass, they estimated that 247 GWh of energy could be generated during the 2015 harvest (BRABO *et al.*, 2015).

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