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TECHNOLOGY MAPPING AND CHARACTERIZATION OF BIODIESEL USING COTTONSEED AND PALM OIL IN THE STATE OF BAHIA, BRAZIL

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ABSTRACT: Biodiesel produced from cottonseed and oil palm is discussed, foregrounded on articles retrieved from databases, coupled to the characterization of the above prime matters within a life cycle approach in the state of Bahia, Brazil. Technical visits in two producing areas were undertaken for better information on biodiesel stages, namely the western and southern regions of the state of Bahia respectively for cottonseed and oil palm. The productive stages of the two cultures are very different: whereas cotton is characterized as agribusiness with intensive fertilizers and pesticides, the oil palm is predominantly grown by familial farms with low technological level. The biodiesel production unit lies more than 800 km from the extraction site, in the case of cottonseed, and approximately 210 km distant in the case of oil palm. Current study delineates the two productive chains and aims at further research to assess their potential environmental impacts.

KEY WORDS: Life cycle assessment (LCA); Biodiesel; Cottonseed; Oil palm.

MAPEAMENTO TECNOLÓGICO E CARACTERIZAÇÃO DO BIODIESEL USANDO CAROÇO DE ALGODÃO E PALMA NO ESTADO DA BAHIA, BRASIL

RESUMO: O artigo discute aspectos relacionados ao biodiesel produzido a partir do caroço de algodão e da palma utilizando base de dados de artigos, bem como a

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caracterização dessas matérias-primas com uma abordagem do ciclo de vida no Estado da Bahia - Brasil. Para um melhor entendimento das etapas do biodiesel, fizeram-se visitas técnicas em duas regiões produtoras: no Oeste (algodão) e no Baixo Sul (palma) da Bahia. As etapas produtivas da agricultura destas duas culturas são muito diferentes: o algodão é caracterizado por ser do agronegócio, com uso intensivo de fertilizantes e pesticidas, enquanto que a palma é cultivada predominantemente pela agricultura familiar com baixo nível tecnológico. A unidade de produção de biodiesel fica a mais de 800 km do local de extração do caroço de algodão, e a cerca de 210 km de distância do dendê. O estudo serviu para delinear essas duas cadeias produtivas, visando trabalhos futuros para quantificar os potenciais impactos ambientais.

PALAVRAS-CHAVE: Avaliação do ciclo de vida (ACV); Biodiesel; Caroço de algodão; Palma (dendê).

INTRODUCTION

Decrease in fossil fuel consumption has been the subject of discussions worldwide due to the negative effects of gas emissions in the environment, especially greenhouse gases. Biodiesel is an alternative to diesel since it is derived from vegetal oil that suits the type of specific raw material of each region. One of the determinants of long-term economic viability of biofuels is their competition with the food industry for the same resources, such as land, labor and water. The debate between food and the first generation of biofuels had raised doubts on the cultivation´s conversion efficiency for the production of energy. Competition with food is a major concern when investing in biofuels (ELBEHRI et al., 2013) whilst benefits to the environment depend on the production system, technology, resources, operating practices and waste management (SILALERTRUSKSA and GHEEWALA, 2012).

Current study is a preliminary analysis of the biodiesel production chain from cottonseed and oil palm. Technological articles from databases and the characteristics of prime matter were retrieved due to gaps in studies on Life Cycle Assessment, in the state of Bahia, Brazil.

1.1 GOVERNMENT INCENTIVE PROGRAMS FOR BIODIESEL IN BRAZIL AND BAHIA

The Program for Production and Use of Biodiesel (PNPB) was developed by the Brazilian federal government to investigate the technical, social, economic and regional characteristics in the production of oil. Law 11,097 of January 2005, which established the mandatory addition of a minimum percentage of biodiesel to diesel oil in sales to consumers (MME, 2014), set a 5% target for 2013, which was already reached in 2010 (MME, 2014; ANP, 2014). Law 13,263 published on March 23, 2016determined an increase to 8% until March 2017 in biodiesel (BRASIL, 2016).

The administration of the state of Bahia, Brazil,established the State Program for Bioenergy (BAHIABIO) by Decree 10,650 of December 5, 2007 (SEAGRI, 2008). BAHIABIO aimed at (1) the creation and development of activities for this end;(2) the development and use of biomass; (3) the dissemination of biodiesel as an additional biofuel energy matrix; (4) new research related to the program. The biodiesel production goals comprise the following raw materials: cottonseed, castor bean, peanut, sunflower, jatropha, palm oiland soybean. It should be underscored that beef fat, oils and fat wastes were not covered by the national and state programs.

The main raw materials for the production of biodiesel in Brazil are soybean,with the highest percentage (73.1%), cattle fat with 22.5% and cottonseed oil (1.9%). Another important focus of the PNPB is the production of biodiesel from various raw materials. Castor bean and palm oil were greatly highlighted by the government in the initial phase, even though later any oil produced by familial farms was considered. In practice, conditions were quite different since soybean and cattlefat currently compete for the biodiesel market (MME, 2014).

In the case of the northeastern region of Brazil, in 2013, the soybean oil was also the main raw material, with an average of 59%; followed by cattle fat (22%); cottonseed oil (14%) with a greater rate than the national average; and palm oil (2%) (Figure 1). In the months in which the use of soybean oil is lower, there is an increase in the consumption of cattle fat feedstock (ANP, 2014).

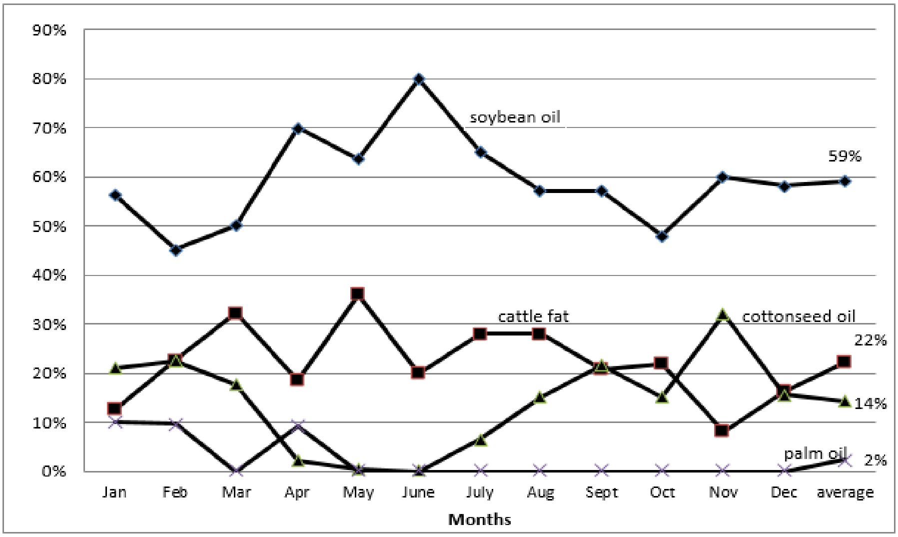

Figure 1. Main raw materials used for biodiesel in the Northeast Region in 2013.
Source: ANP (2014).

Taking into consideration the plants´capability in generating energy for biomass energy, specific features are analyzed for the availability of oil content and oil yield per hectare allocatedto biodiesel production. Table 1 shows the characteristics of the main oil classified by vegetable oil yield (kg / ha).

Table 1. Major oil for biodiesel production in Brazil

Oils	Oil Content	Approximate Yield of Vegetable Oil (kg/ha)	Crop Type
Oil palm	26%	4,000	Permanent
Jatropha	37%	2,000	Permanent
Peanut	45%	676	Temporary
Sunflower	44%	667	Temporary
Canola	38%	570	Temporary
Soybean	20%	564	Temporary
Castor	48%	470	Temporary
Cottonseed	19%	361	Temporary

Source:MAPA (2007).

According to Table 1, Jantropa has the highest oil percentage, followed by the Oil Palm in permanent cultures. However, the Castor Palm may be underscored among temporary cultures.

2 MATERIAL AND METHODS

The method was based on secondary documented data, obtained from scientific and technological sources, such as journals and publications in the area of interest, books and institutional sites, such as the National Agency of Petroleum, Natural Gas and Biofuels (ANP); Ministry of Mines and Energy (MME); National Supply Company (CONAB) and the Brazilian Association of Cotton Producers (ABRAPA).

The following collections were selected: Science Citation Index Expanded (SCI-EXPANDED) and Social Sciences Citation Index (SSCI), between 2004 and August 2014, with keywords "life cycle assessment" and "biodiesel". Search was conducted in September, 2014, and Itwas refined in February 2015within the same scope, looking not merely for "life cycle assessment" and "biodiesel" but also the keywords "cottonseed" and "palm oil", separately.

Two producing regions received visits by technical experts so that the biodiesel production chain could be analyzed in depth. The first one was concentrated in southern Bahia (2012) where three palm-oil extraction and refining units were visited in Nazaré, Nilo Peçanha and Taperoá- BA- Brazil, coupled to a visit to familial farms.

The second one occurred in western Bahia on the farm of a cottonseed producer, an agricultural planting and processing units (cotton gin) in São Desidério and oil extraction in Luis Eduardo Magalhães, Brazil.

Two plantations were visited between 2013 and 2014 to analyze cotton crop and processing in the region of the municipality of São Desidério, Brazil. Two crushing mills for the mechanical extraction of oil were also visited, during the same period, in the municipality of Luís Eduardo Magalhães, Brazil. There were also two meetings. An agronomic engineer, an expert in management and fertility of soil, and who worked with farmers of the region, was present in the former. The second meeting was held with ABAPA technicians in Barreira, Brazil, where the certificate given by the Program for the Commitment of Brazilian Cotton (PCBC) was discussed, coupled to the implantation of the Better Cotton Initiative (BCI).

The documentary section and the technical visits foregrounded the preparation of the results.

3 RESULTS AND DISCUSSION

3.1 LIFE CYCLE ASSESSMENT OF BIODIESEL

The Web of Science database was used as a search strategy on the use of LCA for biodiesel. The terms used were "life cycle assessment" and "biodiesel", with 413 documents. Figure 2 illustrates the distribution of annual publications.

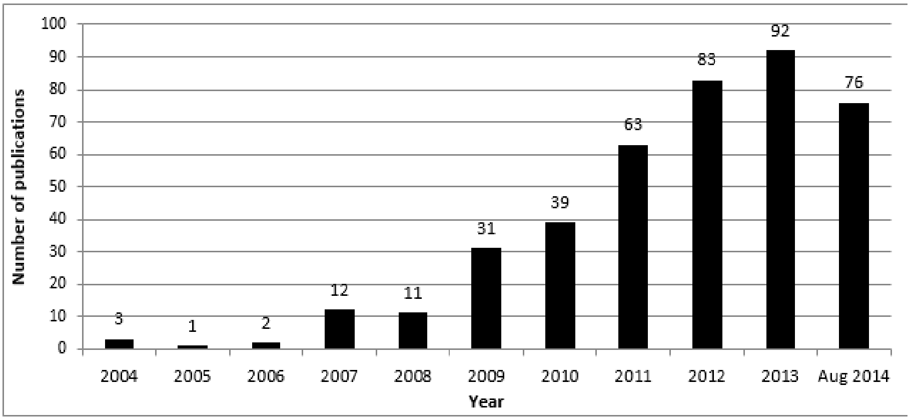

Figure 2. Publications with the terms "life cycle assessment" and "biodiesel", between 2004 and August 2014
Source: Web of Science, 2014.

It may be observed that the annual evolution of publications from 2004 to 2006 was slow but increased in 2007; number of publications increased between 2009 and August 2014. The above is a clear indication that information on biodiesel LCA becomes widespread over the years and attracts the interest of the scientific community on the subject. The analysis of titles of the 413 documents by the terms "Brazil" and"Brazilian" revealed there were ten articles of interest. It is noteworthy that they were published after 2008, the year when the PNPB law on the mandatory use of biodiesel was published.

Further, the search´s scope was refined as from February 2015, by going beyond the preliminary keywords "life cycle assessment" and "biodiesel" and adding "cottonseed". However, no documents were found for the combination. Search in the literature on cottonseed was expanded to other databases, highlighting Matlock et al. (2008), Matlock and Clayton-Niederman (2009) and Clayton-Niederman et al. (2010) who studied the cotton life cycle from the environmental approach. Hebner and Allen (2010) analyzed oil cottonseed for biodiesel and used the power consumption of impact assessment methods, uses of water, land and air emissions, including global warming potential.Finally, research included the term "palm oil", with 82 documents. Analysis of the publications as to their countries of origin was conducted, featuring Malaysia (13), Brazil (9) and Indonesia (8) (Figure 3). According to FAS / USDA (2015), within the global context, Indonesia, Malaysia, Thailand, Colombia and Nigeria were the main producers of palm oil in the 2013-2014 harvest. The production factor may have triggered academic interest in research in these countries.

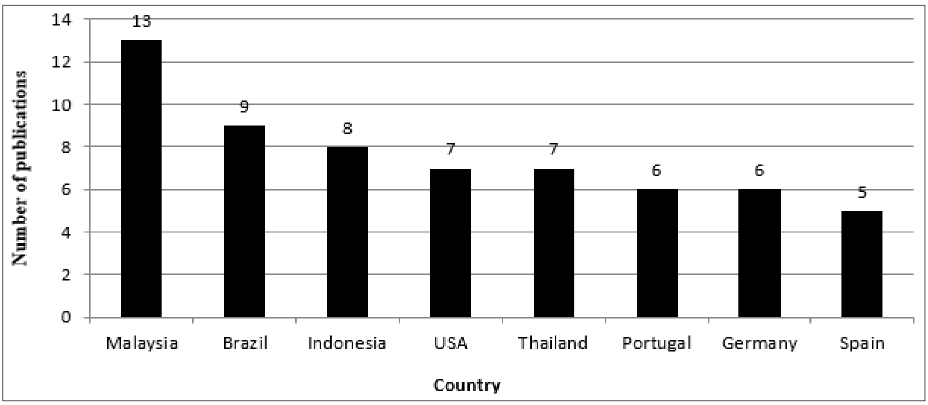

Figure 3. Countries with the highest rates of academic publications for the terms "life cycle assessment", "biodiesel" and "palm oil"
Source: Web of Science, 2015.

The environmental impacts of the palm oil life cycle in the state of Pará, Brazil, were analyzed by Delivand and Gnansounou (2013); Frazão et al. (2013); Rodrigues et al. (2014) and Queiroz et al. (2012). Investigations by Angarita et al. (2009) included a comparison on the energy balance of palm oil life cycle between Colombia and the state of Bahia, Brazil.Current study comprised two crop areas and three palm oil plants in the southern region of the state of Bahia, Brazil, and also three plants in different plantation regions of Colombia. The use of fertilizers is not very significant in the case of the Brazilian areas. Fertilizers are used in small amounts in plantations during the plants´ adult phase. In fact, a limited use of fertilizers in palm plantations in southern Bahia caused low productivity rates and low energy uptake.

3.2 COTTONSEED

3.2.1 General Characteristics

Brazil is among the five biggest world cotton producers, including China, India, USA and Pakistan (ABRAPA, 2014). China, India, USA, Turkey and the European Union are highlighted for world production of cottonseed oil in 2013-2014 (FAS / USDA, 2015). Further, the states of Mato Grosso and Bahia feature the highest percentage (over 80%) of cotton production in Brazil (CONAB, 2014).

In the Brazilian agricultural system, the enterprise production system corresponds to 97% of the volume with heavy intermediate and advanced stages of technology, characterized by machinery, equipment and supplies (NEVES and PINTO, 2013).

Cottonseed contains gossypol which acts as a plant defense agent. However, due to toxicity, its use in seed-derived products, such as oil and protein, has limited application for human consumption and monogastric animals, such as pigs and poultry (ZHOU et al., 2013; KENAR, 2006). As a result, consumption of edible oils from cottonseed is possible after the extraction of gossypol (BARROSO and HOFFMANN, 2011). The intake of gossypol affects animal reproduction, due to males´ reduced fertility (GADELHA et al., 2011).

The seeds used in agriculture are mostly Genetically Modified Organisms (GMOs). GMOs require approval by the Brazilian authorities which authorizes cotton crops for planting and marketing in Brazil (MAPA, 2011). GMO seeds are resistant to insects and tolerant to herbicides. Table 2 shows the list of approved varieties. The first GMO seeds approved in Brazil were Bollgard I produced by Monsanto in 2005 (MCT / CNBio, 2013).

Table 2. Genetically modified cotton authorized in Brazil

CHARACTERISTIC	COMMERCIAL NAME	COMPANY	YEAR
Insect Resistant	Bollgard I	Monsanto	2005
	Bollgard II	Monsanto	2009
Herbicide Tolerant	Roundup Ready	Monsanto	2008
	Liberty Link	Bayer	2008
	GlyTol	Bayer	2010
	MON88913	Monsanto	2011
	GTxLL	Bayer	2012
Herbicide Tolerant and Insect Resistant	Bollgard I Roundup Ready	Monsanto	2009
	Widestrike	Dow Agrosciences	2009
	TwinLink	Bayer	2011
	BollgardII Roundup Ready Flex	Monsanto	2012

Data from MCT / CNBio (2013).

Search has been developed for the genetic improvement of cotton cultivars adapted to conditions of the Bahia savannah (“cerrado baiano”). The studies were conducted as a joint venture with the Brazilian Agricultural Research Corporation (Embrapa), Bahia Foundation and the Bahia Corporation for Agricultural Development (EBDA). BRS 368RF was the first transgenic cultivar available to producers by the program, featuring production potential, tolerance to glyphosate herbicide and virus resistance (BOGIANI et al., 2014).

For a better agribusiness-dominated cotton scenario, the Brazilian agricultural authorities implemented in 2012 a national certification scheme called Brazilian Responsible Cotton (ABR), developed by the Brazilian Association of Cotton Producers (ABRAPA) in partnership with state associations. The Bahia branch is called Association of Cotton Producers of Bahia (ABAPA).

The certification covers social (general laws on rural labor and safety, occupational health and environment of rural labor), environmental (good agronomic practices and management including water, soil and environment, pest and transgenic varieties) and economic aspects (harvesting, processing and storage of cotton) (ABRAPA, 2014).

During the 2013-14 harvest there was a unification of the two programs whereby the producer, if approved in the certification process, obtained the ABR certificate and was licensed by Better Cotton Initiative (BCI), which is optional and serves to improve world cotton production (ABRAPA, 2014). In the 2013-2014 harvest, the number of Brazilian farms that were ABR- and BCl-certified reached respectively 254 and 212. There were 33 ABR- and 26 BCI-certified farmsin the state of Bahia (Table 3).

Table 3. ABR-certified and BCI-licensed farms – 2013-2014 harvest

STATE	ABR CERTIFICATION	BCI LICENSING
Bahia	33	26
Goiás	16	15
Maranhão	2	2
Mato Grosso	188	154
Mato Grosso do Sul	4	4
Minas Gerais	11	11
Total	**254**	**212**

Data retrieved from ABRAPA (2014).

The certification and licensing brought a systematized organization in the management of the cotton agribusiness segment, featuring a breakthrough in the industry. However, environmental aspects were not yet considered in the entire production cycle with regard to natural resources, raw materials and wastes generated in the process.

According to Neves and Pinto (2013), approximately 70% of thecottonseeds are produced for oil-processing industries; 25% for livestock meals, milk and feedlots, and 5% for seed production. It has been estimated that the allocation percentage for livestock has been higher in 2011, approximately 40%, decreasing with new industry demands.

The production of biodiesel using cottonseed oil stages of the production chain comprises crops, processing cotton gin, crude oil extraction, oil refining and biodiesel production. In agriculture, there is the process of growing and harvesting of cotton on the farms. After cotton is separated from the core and fibers in the processing plant, the cottonseeds are transported to the refinery industries where crude oil is extracted and treated to produce biodiesel.

3.2.2 Stages of Cottonseed to the Biodiesel Production Cycle

The herbaceous cotton (*Gossypium hirsutum* L. r. Latifolium Hutch.) grown in western Bahiais characterized by large, mechanized, non-irrigated plantations, called dry cotton planting. The cotton crop in the region is planted between November and February (spring and summer), with harvest between May and September (fall and winter) (CONAB, 2014).The main phases for the cottonseed biodiesel production are: agriculture, cotton gin, oil extraction, oil refinement and biodiesel production (Figure 4).

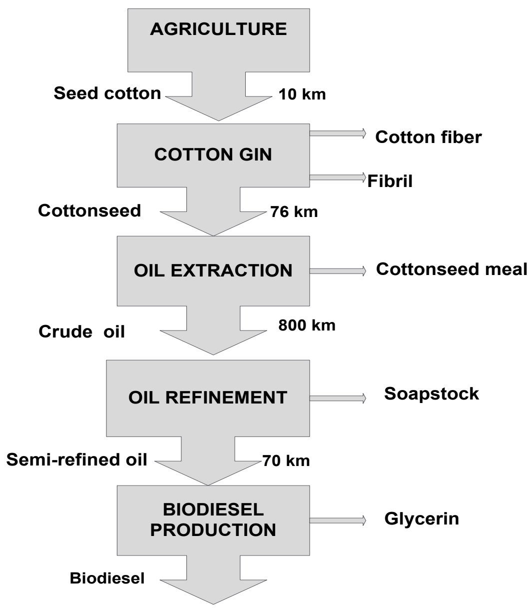

Figure 4. Production chain of biodiesel from cottonseed

The main inputs for cotton crops comprise fertilizers that provide nutrient to the plant; corrective agents used to correct soil acidity; pesticides (herbicides, insecticides and fungicides) against the plant´s invaders; defoliants and maturing, for the optimization of harvest performance.

Chemical fertilizers are required for high cotton production in the savannah of Bahia, but their production sources are distant from the cotton growing areas (NEVES and PINTO, 2013). The above causes environmental impacts ranging from production, use and the great distances covered by these products.

Soil pH is corrected with lime and fertilized with nitrogen, phosphate and potassium macronutrients, coupled to micronutrients (boron and sulfur). Inputs are organophosphorus products, nitrogen, pyrethroids, and others. The use of fuel is associated with agricultural machinery in cultivation and transportation activities on the farm involving cotton bales with seeds. The waste generated from the empty pesticide containers are disposed of in two receiving stations in the region. These collection points designed these boxes for recycling from the manufacturers.

After harvesting the seed cotton is pressed and transported to the cotton gin for an average distance of 10 km. After than is received in the processing plant (cotton gin) for the cleaning and separation processes, with cottonseed, cotton fiber, and fibril as final products. Since a portion of the wastes generated is used to power the boiler, the costs of removing and discarding fuel demands for the generation of steam used in the wetting of the fibers are minimized.

In the next stage of oil extraction, approximately 76 km distant from the cotton gin extraction, the cottonseed is stored, screened, crushed, cooked and pressed to produce crude oil and cottonseed meal. The cake is sold as animal feed, whilst the crude oil is decanted, centrifuged and stored in tanks.

Crude oil is sent to a refining companyin Feira de Santana some 800 km distance from the oil extraction plant, where the semi-refined oil and refinement soapstock is produced. The semi-refined oil is then sent to the biodiesel production facility in Candeias, some 70 km far from the place of production of refined oil, to produce biodiesel and glycerin.

3.3 OIL PALM

3.3.1 General characteristics

Oil palm (*Elaeis guineensis*) is a plant native to Africa, but naturalized in the humid tropical climate of the coast of Bahia. The oil palm was later exported to northern Brazil where it was grown on a commercial scale. Dura and Tenera are the two predominant varieties of the species. The former is resistant to pests and diseases; it coexists with weeds; it features good agro-climatic adaptation; and has a 40-year production life. The variety, however, has low yield per hectare, around 4-6 t / ha a year, and low oil yield, around 16%. The latter variety is a hybrid species and is mostly cultivated by producer countries,with approximately 30 t / ha per year, with yield in oil production around 22%. The variety has a short life span, averaging 25 years, and is highly demanding in nutrition. Further, it is only slightly resistant to pests. The oil palm in Bahia is of the Dura variety, characterized as sub-spontaneous and, consequently, of low income (CASTRO et al., 2010; SANDE, 2002).

The cultivation of the oil palm is characterized as that which produces more oil per unit area planted, among all existing oil trees, mapped in Brazil (SILVA, 2005).The oil palm produces fresh fruit bunches (FFB) from which are extracted palm oil (extracted from the mesocarp) and palm kernel oil (extracted from the seed) (CONAB, 2006). As for the palm oil in Bahia, the production stages comprise cultivation, oil extraction and biodiesel production.

Data by IBGE / PAM (2010) show that Para, Amazonas and Bahia are the Brazilian states that produce palm oil, with Para as the most important producer in Brazil. The harvest area in Bahia (53,726 ha) is slightly greater than the area in the state of Para (52,244), but the amount produced (ton) is lower (4.5 times lower) (Table 4). The municipalities of Valença, Taperoá, Camamu and Cairu (all in the state of Bahia) were the largest producers of palm oil in the state for the 2011 and 2012 harvests (SEAGRI, 2012).

Table 4. Palm oil production in Brazil, by producer state

Region in Brazil	Area for cultivation (ha)	Area cultivated (ha)	Quantity Produced (t)	Productivity (kg/ha)	Production Value (1 000 R$)
North					
Amazonas	2,949	450	3,060	6,832	1,242
Pará	52,244	52,244	1,058,381	20,258	193,279
Northern Region	**55,193**	**52,694**	**1,061,441**	**20,143**	**194,521**
Northeast					
Bahia	**53,726**	**53,726**	**231,272**	**4,305**	**38,347**

Data by IBGE/PAM (2010).

The state of Bahia has an available area of 1,237,703 hectares, including preference and regular areas, with excellent weather conditions for the production of the oil palm, as reported in the agro-ecological zoning included in the Decree 7172 / 2010. The area planted with oil palm in Bahia is currently only 4.3% of this huge area available (BRASIL, 2010; IBGE, 2014).

Data of the Brazilian Association of Biodiesel Producers in Brazil (APROBIO, 2012) show that Brazil consumes 520,000 t of palmoiland 200,000 t of palm kernel oil, with a total production of approximately 240,000 t of palm oil and 23,000 t of palm kernel oil. This means that there is a curbed demand in Brazil, with importsreaching 280,000 t of palm oiland palm kernel oil 177,000 t to meet demands of the country´s industries.

3.3.2 The Production of Palm Oil for Biodiesel Cycle Stages

Oil palm tree is a permanent, extractive and traditional crop. Due to these factors, farmers do not make proper use of treatments, fertilizers, pesticides and agricultural practices since it is considered a secondary produce in their farms. The main phases for palm oil for biodiesel are: agriculture, oil extraction and biodiesel production (Figure 5).

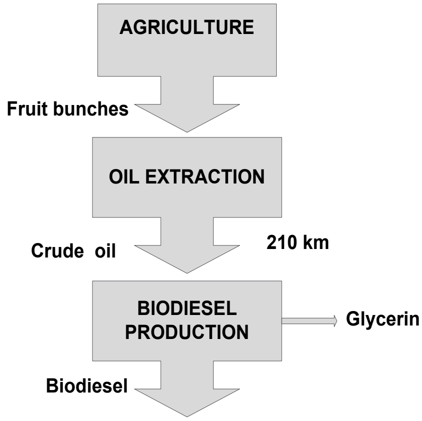

Figure 5. Production chain of biodiesel from cottonseed

According to Castro et al. (2010), harvesting in southern Bahia is done by hand when the fruit reach a high degree of maturity. The fruit is transported to the crushing plant in the shortest possible time. Although transportation is mechanized, it depends on the distance between the farm and the crushing plant.

Oil extraction consists of reception and storage of curls, sterilization, bunch threshing, digestion, pressing, settling and drying (FERNANDES, 2009). Two types of crude oil (palm oil and palm kernel oil) are extracted from the fruit bunches. After the separation of palm oil, the solid (stearin, used to manufacture soap) and liquid (olein, commercialized for the food industry) fractions are extracted. The production of palm oil for biodiesel is transported to a mill 210 km away.

The palm kernel oil, comparable to coconut oil, is used in the food industry. As a co-product of the oil extraction process,it yields the palm kernel cake used for animal feed and fertilizers; fiber (after extraction, the fruits are popularly known as bushings) to generate energy (burning in boilers) and fertilization; nuts (shells) that are crushed and used as fertilizer, animal feed and power generation and coal additives; and leaves for crafts and feed.

Two big palm extraction plants may be underscored in Southern Bahia. The company located in the municipality of Taperoá is characterized by also having its own production segment with a set of farms with a total area of 3,270 hectares (OPALMA, 2015). A producer of palm oils is also extant in the municipality of Nazaré, with an installed processing capacity of about 20 tons of FFB / hour (ODELSA, 2015).

According to CONAB (2006), in addition to these two companies, there is another differentiated segment of palm business in Bahia, known as "roldões", which are the old and traditional oil processing units. They provide palm oil for the manufacture of "acarajé" (typical African-Bahia cuisine food), small local restaurants and consumers of the southern coast and Reconcavo Region. The weaknesses of the industrial process comprise lack of technical guidelines; low yield in oil extraction; loss of parts of the feedstock for production; production of low quality oil; significant negative environmental impact due to the disposal of effluents in the region´s mangroves.

The production of palm oil in Bahia does not meet the demands of the food industry. Silva (2015) proved this fact in the three industrial companies visited in the southern region of the state. The industries commercialize palm oil as food and to meet their business demands. However, between 50% and 70% of palm oil comes from the state of Pará with low acidity (2-3%) which is then mixed with the Bahia oilwith very high acidity (7-12%). The mixture, called "Brent blend",has a maximum of 5% acidity appropriate for palm products in supermarket chains but fails to meet the biodiesel segment due to its high acidity.

According to data by Leiras (2006), the acidity of the oil obtained by crushing in the southern regionof Bahia ranges between 2.5% and 5.5%, but it is used as a feedstock vegetable oil with a maximum of 1% acidity. The problem may be solved by local logistics and by reducing the time between harvesting and processing.

Current research has proved that, although there is great land availability in Bahia, farmers are not expanding their palm oil plantations due to economic, technological and cultural factors. These factors comprise (1) difficulties in production, purchase insurance, logistics; (2) bureaucratic issues in accessing credit and strong default; (3) lack of training and technical assistance; (4) conflicts with trade unions and cooperatives; (5) resistance to replace the "Dura" for the "Tenera"palm with higher productivity, due to economic issues such as its long span of time to start producing; (6) religious beliefs (the"Dura"palm belongs to the Candomblé culture) and consequently resistance by middlemen, immersed in the region´s religious beliefs, to adopt the "Tenera" oil palm allegedly not appropriate for making palm oil.

4 CONCLUSIONS

Mapping carried out in the Web of Science revealed that there has been a growing trend of publications over the years and that information on biodiesel LCA is widespread and increasing. One may thus predict that this evolution generates future jobs and attracts the interest of companies, especially the biodiesel LCA produced from cottonseed still in development.

After mapping the technological articles, the production chain of cottonseed and oil palm for the production of biodiesel was defined. The cottonseed production chain may be characterized by agribusiness agriculture, located in the western region of Bahia. On the other hand, the agricultural chain of oil palm foregrounds family agriculture, located in southern Bahia. The biodiesel production unit lies more than 800 km from the extraction site, in the case of cottonseed, and approximately 210 km distant in the case of oil palm.

Palm oil is not a factor in the competitive market for biodiesel production in Bahia. Technical, economic and environmental aspects are not feasible in the current structure, especially with regard to food competition.

The use of biodiesel in the Brazilian energy sector has a number of advantages and disadvantages with regard to energy, economic, social and environmental issues. From the life-cycle approach of these two oils, the authors suggest the Life Cycle Assessmentas a viable proposal for the study of the potential environmental impacts of the biodiesel production chain in the state of Bahia.

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