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SUSTAINABILITY STUDY OF BIODIESEL FROM *Acrocomia totai*

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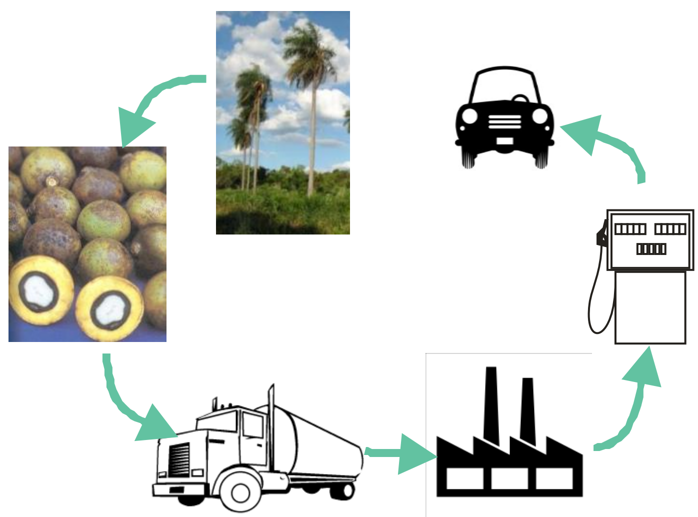
ABSTRACT

The aim of this work is to quantify the life-cycle emissions in terms of CO_2 equivalent grams per megajoule of biodiesel produced from Acrocomia totai, a native oily seed from Paraguay, according to Directive 2009/28/EC. The other key point is to calculate the amount of energy invested to get a megajoule of biodiesel, by means of two different ratios: the EROI (Energy Return On Investment) and the FER (Fossil Energy Ratio).

The LCA (Life Cycle Assessment) performed considers the following steps: harvesting, transportation, oil extraction from the fruits, transportation of the vegetable oil, oil conversion to biodiesel, distribution and combustion of the biodiesel. In this case, two different scenarios have been considered: Scenario 1: full distribution in Paraguay; Scenario 2: exportation to European countries, such as Spain.

The first set of results is the emissions in each step of the LC (Life Cycle) as well as the total emissions. The second set of results is the energy ratios. The GHG emission saving is 86.69 % with respect to the LC greenhouse emissions from Diesel EN-590 (with a default emissions value of 83.8 g CO_{2e} $MJ_{diesel-1}$) for Scenario 1 and 74.24 % for Scenario 2.



Keywords: Life cycle analysis, Greenhouse emissions, EROI, Fossil Energy Ratio

1. Introduction

Life Cycle Assessment (LCA) is an accurate tool to quantify the environmental burdens of any product or process from a cradle to grave perspective. This analytic tool systematically describes and assesses all flows that enter into the studied systems from nature and all those flows that go out from the systems to nature, all over the life cycle.

The interest in LCA started in the 1990s and since then a strong development has occurred. The practice of LCA is regulated by the international standard ISO 14040 and 14044 (ISO, 2006 a,b), and there are several introductions (Guinée *et al.*, 2002; JRC IES 2010) and databases (Ecoinvent, 2007) available.

LCA is a robust and mature methodology although some aspects are still under development. A thorough review of the recent advances of the methodology can be found in Finnveden et al (2009). In particular the accuracy strongly depends on the hypothesis used. The scope of the analysis (i.e. soil to tank studies or soil to wheel studies), the limits considered in each stage, the allocation methods or the reliability of the data used in the calculations are basic points that should be established in the methodology, due to their huge influence in the final results. There are plenty of LCA studies applied to biofuels, (see Menichetti *et al.* (2009) for a review of them) with different hypothesis and results. The debate on the actual benefits of biofuels that emerged in 2008 with the publication of the study of Searchinger *et al.* (2008) has raised the issue of the effects of indirect land use change on biofuels LCA results, an example on how different assumptions can alter the results of LCA studies.

Knowledge about sustainability of biofuels is still in question and in order to support the policy making process broader methodologies are required that take into account not only environmental aspects of sustainability but also that address societal and economic sustainability. Several methodologies have been proposed to date including Life Cycle Sustainability Assessment (UNEP/SETAC 2011), Cost benefit Analysis (IISD, 2013) and Multicriteria Analysis (Ziolkowska, 2013).

Directive 2009/28/EC was approved for the regulation and the promotion of renewable energies, and established a mandatory methodology to assess the sustainability of biofuels in terms of greenhouse gas emissions. Since then onwards, LCA studies related to biofuels have followed a more homogeneous methodology and their results are more comparable. Pre-directive LCA studies were not comparable due to the huge differences in the calculation methods used, as stated by Cherubini and Stromman (2011). The same happens with the comparison between energy ratios resulting from different pre-LCA studies (Zhang and Colosi, 2013).

Directive 2009/28/EC is currently under review (COM(2012) 595). This document proposes two key points: the first one is to consider the indirect land use change emissions (ILUC emissions) in the life cycle. These emissions are a consequence of the land use change emissions (LUC emissions) because a change in the carbon stocks of an area sometimes means that the crops that were being harvested in that area must be harvested in a different area in the future, which means that the carbon stocks of another area would change. The second one is the attempt to limit the use of conventional biofuels (biofuels from oil seeds).

In the case of biofuels with well-known cropping and production processes, the directive proposed default CO_2 equivalent emission values that characterize the sustainability of these biofuels. These values are useful as a quick estimation of the biofuel sustainability. Obviously, there is no default value for *Acrocomia totai* biodiesel, because its production is very marginal, and therefore, its sustainability must be calculated following the methodology proposed in the directive.

On the side of energy sustainability, energy indicators such as primary energy and fossil energy have been used as recommended in (Arvidsson *et al.*, 2012).

2. Characteristics of Acrocomia totai

Acrocomia totai is a relatively unknown feedstock in Europe but very common in Paraguay and all over South America. It is a palm used since long ago for feeding animals and making soaps, among other uses. It grows without human action in most of the Paraguayan territory and great oleaginous performance can be obtained without pesticides or fertilizers. Also growing the seeds is not necessary. A biodiesel fuel can be produced from its fruits: a kind of drupes similar to small coconuts.

From these fruits, two types of oils with different fatty acid profiles are obtained: pulp oil and almond oil. These oils are mixed before transesterification. The fatty acid profile of *Acrocomia totai* biodiesel is shown in Table 1, together with some of its properties. This biofuel is currently being produced in Paraguay by COPEBIOSA (Compañía Paraguayo Española de Bioenergía S.A.) in relatively small quantities.

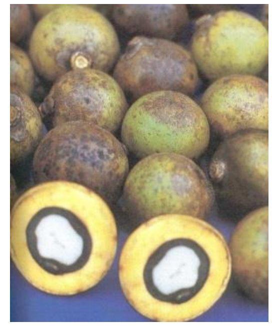



Figure 1. *Acrocomia totai* trees and fruits

Table 1. Properties of *Acrocomia totai* biodiesel.

Fatty acid profile	% m/m	Parameter	Value
Capric	1.79	Formula	$C_{16.64}H_{32.37}O_2$
Lauric	18.37	Mean molecular weight	264.50 g mol^{-1}
Miristic	5.38	Iodine number	44.01
Palmitic	27.46	Cetane number	66.7
Stearic	3.58	Density (15ºC)	873.3 kg m^{-3}
Oleic	35.77	Higher heating value	39.43 MJ kg^{-1}
Linoleic	7.65	Lower heating value	36.78 MJ kg^{-1}

3. Methodology

The LCA tool has been used. This methodology considers all the stages involved in the process of production and distribution of *Acrocomia totai* biodiesel from oleaginous fruits harvesting to combustion of biodiesel (soil to wheel life cycle), as established in Directive 2009/28/EC, which sets a common framework for the calculation of the environmental burden of biofuels. The stages considered within the life cycle are: fruit growth and harvesting, transportation, oil extraction from the fruits, the transportation of vegetable oil, biodiesel production, distribution and combustion of biodiesel.

The amount of CO_2 released during the combustion of biodiesel and the use of other co-products are considered nil, since Directive 2009/28/EC assigns a zero value to emissions from use of all biofuels, considering that carbon has been captured by plants in their growth. This is also a result of the Decision of the Commission on July 18, 2007, which assigns a zero emission factor for biofuels. However, in the process of obtaining biodiesel, different chemical agents are used some of which are part of the biodiesel compound, and therefore, emissions from the non-renewable part of this biodiesel must be considered. In this case, emissions associated to methanol are quantified as if it is burned and the methanol emission factor is assigned correspondingly (Intelligent Energy Europe, BioGrace, 2013).

As functional unit, 1 MJ is used, although different units have been used at each stage to complete the intermediate calculations in an easy way, such as:

- Harvesting: 1 ha of coconut area.
- Transportation of the fruits: 1 kg of vegetable oil.

- Oil extraction: 1 kg of vegetable oil.
- Oil transportation: 1 kg of vegetable oil.
- Biodiesel production: 1 kg of biodiesel.
- Biodiesel distribution: 1 l of biodiesel.

The choice of the correct limits of the system is a key point. Here in this study the chosen limits are the following:

- Technological limits: manufacturing of the machinery used at each stage of the production process as well as the construction of the oil extraction plant and biodiesel production plant are excluded from the system.
- The spatial boundaries are the borders of Paraguay and the borders of the EU, due to the possibility to commercialize this biodiesel within the EU.
- The time horizon is 4 years (because in 2017 the mandatory minimum emissions savings of greenhouse gases change from 35% to 50%).

According to Directive 2009/28/EC, the formula is:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee} \quad (1)$$

where e_{ec} are the emissions from the agricultural activity, e_l are the emissions associated with the land changes, e_p are the emissions from oil and fuel processing, e_{td} are the emissions from transport and distribution, e_u are the emissions from the fuel use, and e_{sca}, e_{ccs}, e_{ccr}, and e_{ee} are the emission savings from soil carbon accumulation via improved agricultural management, carbon capture and sequestration, carbon capture and replacement and excess electricity, respectively. Emissions are given in grams of CO_2 equivalent (CO_{2e}), i.e., grams of CO_2 that would cause the same level of radiative forcing as a given grams of a greenhouse gas. The global emissions are compared to the default emission value for diesel EN-590 given in the directive 2009/28/EC. Thus, with both values the emission savings are obtained. Also, the compliance with the sustainability requirements displayed in Article 17 of Directive 2009/28/EC has been evaluated, in order to facilitate the possible future commercialization of *Acrocomia totai* biodiesel in Europe.

All data from the agricultural production stage and the energy and raw materials required in the oil extraction plant and biodiesel production plant have been provided by COPEBIOSA. Also data from the distribution stage were provided by them. The exhaust emissions from the vehicles used in the transportation of the fruits, oil and biodiesel (trucks to transport the fruits and 28-ton tanker trucks for the transportation of oil and biodiesel) have been obtained from Intelligent Energy Europe BioGrace (2013). Other specific data have been obtained from the ETH database, BUWAL 250 and ECOINVENT. Although some data from these databases are valid for conditions similar to those of Switzerland and of West Europe countries, they were used here because no databases with values based on the conditions in South America were found. The energy conversion factors (from primary energy to final energy) used are the ones published in Spain by IDAE (Instituto para la Diversificación y el Ahorro de la Energía) (IDAE a, 2005, IDAE b, 2012), because no information is available for Paraguay. However, they have been adapted as closely as possible to the Paraguayan position. For example, in the case of electricity, the Paraguayan energy mix has been considered, as specified in Directive 2009/28/EC.

The emissions are allocated based on the energy content of the products and co-products obtained and considering the final and previous stages involved in the production and distribution system considered for this biodiesel.

The GHGs (Greenhouse Gases) considered are CO_2, methane and nitrous oxide. Their global warming potentials are the ones given in Directive 2009/28/EC.

Two different scenarios are considered in terms of the distribution of biodiesel:

- Scenario 1: Full distribution in Paraguay. This is based in the current distribution of this biodiesel in Paraguay.
- Scenario 2: export to EU through Spain. This is a hypothetical scenario and it considers the most real and efficient combination of possible transportation means.

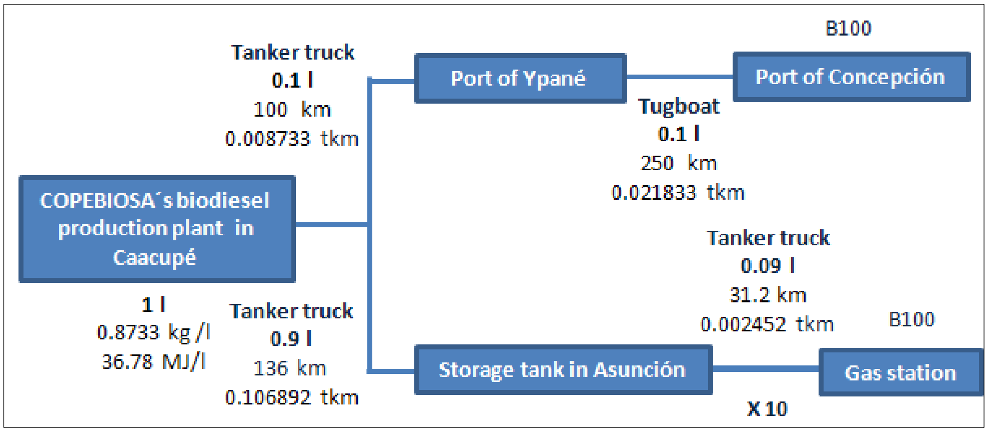


Figure 2. Distribution of *Acrocomia totai* biodiesel in Scenario 1

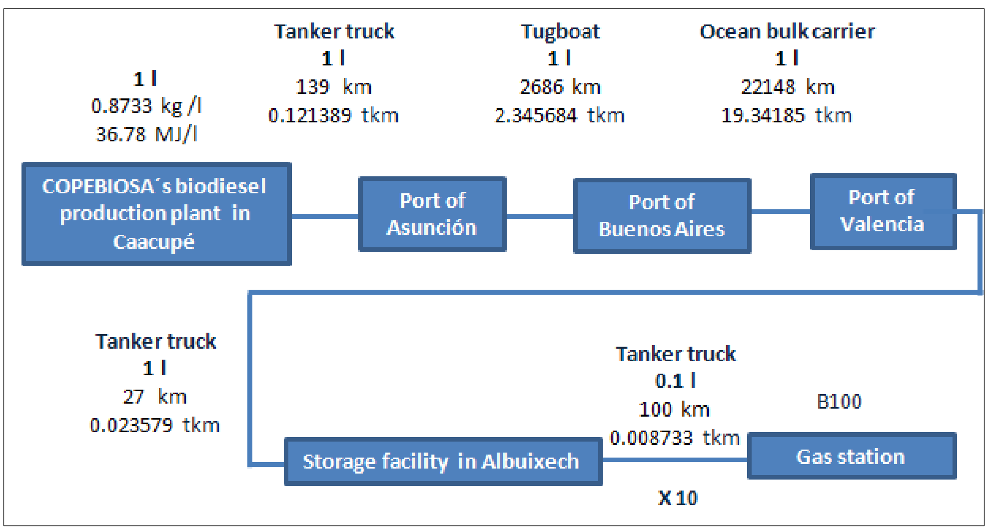


Figure 3. Distribution of *Acrocomia totai* biodiesel in Scenario 2

As a consequence of the differences between the schemes of transportation in each scenario, both shown in figures 2 and 3, the emissions in CO_2 equivalent released to the environment and the energy invested are different in each scenario.

Regarding the energy use in the production and distribution of *Acrocomia totai* biodiesel, two different energy ratios can be considered:

- EROI (Energy Return On Investment), energy efficiency or life cycle energy payback rate: the ratio between the energy of the product, quantified as the lower heating value and total primary energy needed to produce and distribute the product.
- FER (Fossil Energy Ratio): it is the ratio between the energy of the product, quantified as the lower heating value and total fossil energy invested to produce and distribute the product.

- These values are compared with the values of energy use of the Diesel EN-590 produced in Spain and distributed in Madrid in its bus transportation system (García *et al.* 2012). The EROI and FER are compared to the values shown by Lechón *et al.* (2006), which considers the production and distribution of Diesel EN-590 in Spain. This comparison is not established with the diesel sold in Paraguay, because no reliable data about it are available.

4. Results

4.1. Greenhouse gas emissions

Considering the alternative use of agricultural land is necessary because Directive 2009/28/EC includes emissions related to the change in land use. In this case, e_l (land use change emissions) is nil because the palms are already seeded. When palm fruits are harvested, carbon stocks are not modified. Also, indirect land use change emissions (ILUC-Indirect Land Use Change) are zero, since no agricultural activity is moved elsewhere. These ones are not included in the Directive 2009/28/EC, but there is a great discussion about their importance, so they have been considered for information purposes.

Emissions from utilization (e_u) are also nil for biofuels according to directive 2009/28/EC. No emissions savings (such as those associated with excess electricity, carbon accumulation and capture, e_{sca}, e_{ccs}, e_{ccr} and e_{ee}) can be considered in this case. As shown in Table 2, e_{ec} (emissions from the agricultural activity) is almost nil due to the use of manual machines and electrical trucks in the harvesting. It should be noted that there is still no commercial production of this crop in Paraguay, and the studied case is based in the use of current stands of *Acrocomia totai.* In the case that new plantations were stablished, impacts from land use change, crop implantation and growing should also be taken into account.

Emissions from oil extraction and biodiesel production (e_p) have also low values due to the great share of renewable energy sources in the extraction facility and the biodiesel production plant. In addition to this, such low values for both e_{ec} and e_p emissions are derived from the fact that the emission factor of the electrical grid in Paraguay is close to zero (0.4 g CO_{2e} MJ^{-1}, Intelligent Energy Europe, BioGrace, 2013) due to predominance of hydraulic generation. Emissions from transport and distribution (e_{td}) reach higher value for Scenario 2 than for Scenario 1 due to the large distance between Paraguay and the EU. From total emissions (E) for each GHG gas, the GHG emission saving is 86.69 % with respect to the emissions derived from Diesel EN-590 (with a default emissions value of 83.8 g CO_{2e} MJ_{diesel}^{-1}) for Scenario 1 and 74.24 % for Scenario 2.

Table 2. Values for the emissions in both scenarios

Emissions (g CO_{2e} $MJ_{biodiesel}^{-1}$)	Scenario 1	Scenario 2
e_{ec}	0.000004364	0.000004364
e_p	7.6657	7.6657
e_{td}	3.4894	13.9220
E	11.1551	21.5876
E_{CH4}	0.4978	0.4981
E_{N2O}	0.0066	0.0066
E_{CO2}	10.6499	21.0821
Saving with respect to diesel fuel	86.69 %	74.24 %

E_{N2O} has a very low value, slightly above zero. The reason is the use of traditional cultivation techniques with no fertilization (most part of N_2O emissions are typically released in the fertilization process with nitrogen-based fertilizers). CH_4 emissions are mostly due to the methanol used in the transesterification process (0.4955 g CO_{2e} $MJ_{biodiesel}^{-1}$ of 0.4978 g CO_{2e} $MJ_{biodiesel}^{-1}$) and the rest are associated with the methane exhaust emissions from the vehicles.

When *E* (total emissions in the LCA) for both scenarios are compared to the total emissions value for other biofuels, *E* value for *Acrocomia totai* biodiesel is much lower than total emissions of typical 1st generation biofuels (from oil seeds), such as rapeseed biodiesel (80±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Zah *et al.* 2007) sunflower biodiesel (30±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Lechón *et al.* 2009, 27±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Edwards *et al.* 2007), palm biodiesel (51±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Lechón *et al.* 2009, 45±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Renewable Fuels Agency, 2008, 54±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Zah *et al.* 2007) and soy biodiesel (38±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Lechón *et al.* 2009, 60±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Zah *et al.* 2007), and is close to the total emissions value of used oil biodiesel (11±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Lechón *et al.* 2009, 13±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Renewable Fuels Agency, 2008,31±1 g CO_{2e} $MJ_{biodiesel}^{-1}$, Zah *et al.* 2007), as summarized in Table 4 below. This comparison is only indicative because each LCA has been influenced among others by the electrical mix of its respective country and by the values chosen for GHG warming potentials.

4.2. Energy consumption

To compare the energy consumption of both fuels, *Acrocomia totai* biodiesel and Diesel EN-590, the amount of biodiesel that produces the same energy as Diesel fuel EN-590 must be calculated from their LHV (Lower Heating Value). Thus, 1.137847 kg of biodiesel produces the same energy as 1 kg of diesel.

The values of primary energy consumption and fossil energy consumption in the production and distribution of *Acrocomia totai* biodiesel are shown in Table 3 for scenarios 1 and 2, together with the total energy consumption of Diesel EN-590 in the production and distribution (García *et al.* 2012). The savings in primary energy and fossil energy of *Acrocomia totai* biodiesel in scenarios 1 and 2 with respect to Diesel EN-590 are also shown in Table 3. Savings are higher for Scenario 1 than for Scenario 2 in both primary energy and fossil energy. Fossil energy invested in each stage of the LCA is shown in the Figure 4.

Table 3. Primary and fossil energy invested in the life cycle, primary energy saved and fossil energy saved with respect to Diesel EN-590 and energy ratios in scenarios 1 and 2.

Parameters	Fuel		
	Diesel EN-590	*Acrocomia totai* biodiesel	
		Scenario 1 (S_1)	Scenario 2 (S_2)
Primary energy ($MJ_{primary\ energy}\ kg_{diesel}^{-1}$)	49.25	35.81	40.97
Fossil energy ($MJ_{fossil\ energy}\ kg_{diesel}^{-1}$)	48.85	7.69	12.85
Primary energy saved			
(MJ)		13.44	8.28
(%)		27.28	16.81
Fossil energy saved			
(MJ)		41.16	36.01
(%)		84.26	73.70
FER ($MJ_{fuel}\ MJ_{fossil\ energy}^{-1}$)	0.968	5.44	3.26
EROI ($MJ_{fuel}\ MJ_{primary\ energy}^{-1}$)	0.965	1.17	1.02

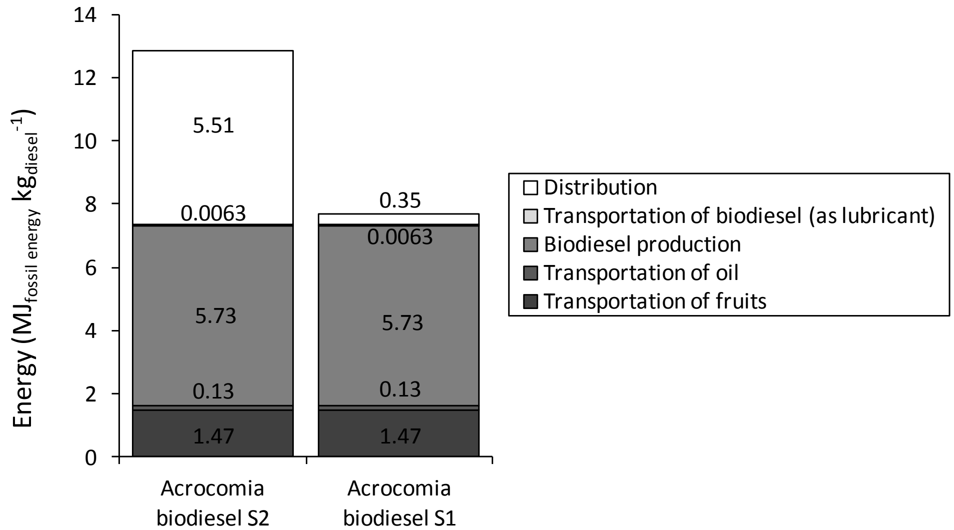


Figure 4. Primary and fossil energy invested in the life cycle

Most of the total fossil energy in LCA is invested in the transesterification process, due to the high demand of fossil energy from the chemical incomes. Also transportation of the fruits (carried by old diesel little trucks with low efficiency) and the distribution process (carried by tanker trucks, tugboats and in the case of scenario two, also with ocean bulk carrier) have high fossil energy consumption. Differences in energy consumption during distribution are due to the great difference in the transportation distance between the two scenarios (see figures 2 and 3). In the other hand, the stages of transportation of oil and transportation of biodiesel produced to be used as lubricant in the cold presses have the lowest values, mostly because the proximity between the extraction plant and the biodiesel production facility. In addition, harvesting and oil extraction processes have nil fossil energy consumption values. This is because in harvesting, electric trucks and manual machinery are used. Also, in the cultivation of the seeds, no pesticides or fertilizers are used. In the extraction plant, all the power supply is provided by solar units and by the electrical grid. This grid electricity is obtained 99.9% from hydroelectrical power plants (Central Intelligence Agency, 2013).

Values obtained for ratios FER and EROI for the *Acrocomia totai* biodiesel under Scenario 1 and Scenario 2 are shown in Table 3. The energy biodiesel releases in combustion is higher than the fossil and primary energy consumed during its production. Thus, EROI is higher than unity in both scenarios. Fossil Energy Ratio values for *Acrocomia totai* biodiesel reach much higher values than for Diesel EN-590 as a consequence of the intense participation of renewable energy on the whole life cycle.

In the case of *Acrocomia totai* biodiesel under scenario 1 (whole distribution in Paraguay), FER and EROI have higher values than the ones obtained for *Acrocomia totai* biodiesel under Scenario 2 (distribution to EU). Even taking the lowest value for FER (Scenario 2), this is in the same range as other values obtained from the literature: higher than FER values obtained for rapeseed biodiesel (2.15±0.05 $MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Edwards *et al.* 2007, 3±0.05 $MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Lechón *et al.* 2009), sunflower biodiesel (2.75±0.05 $MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Edwards *et al.* 2007), palm biodiesel (2.70±0.05 $MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Lechón *et al.* 2009), but lower than used oils biodiesel (20±0.05 $MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Lechón *et al.* 2009), sunflower biodiesel (4±0.05 $MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Lechón *et al.* 2009) and soybean biodiesel (4.75±0.05$MJ_{biodiesel}\ MJ_{fossil\ energy}^{-1}$, Lechón *et al.* 2009), as summarized in Table 4.

To calculate the EROI, the energy of the fruit has been considered, due to the renewable character of the biofuel. Consequently, the EROI from scenarios 1 and 2 are close to 1 and do not reach higher values. If the EROI values of *Acrocomia totai* biodiesel are compared to the EROI values of other biofuels from different

LCA studies from the literature (also summarized in Table 4), it can be observed that these values are lower than the values of Brazilian soybean biodiesel (2.48 $MJ_{biodiesel}\ MJ_{primary\ energy}^{-1}$, Cavalett *et al.*, 2010), French rapeseed biodiesel from homogeneous transesterification) (3 $MJ_{biodiesel}\ MJ_{primary\ energy}^{-1}$, Ecobilan, 2002), English rapeseed (1.78 $MJ_{biodiesel}\ MJ_{primary\ energy}^{-1}$, Richards, 2000) and biodiesel from used oils (5.29 $MJ_{biodiesel}\ MJ_{primary\ energy}^{-1}$, Rowe, 2008) and palm biodiesel in Malaysia (9.60 $MJ_{biodiesel}\ MJ_{primary\ energy}^{-1}$, Yusof, 2006).

These are also indicative comparisons because both FER and EROI depend strongly on the electricity mix, which changes from country to country, and on other factors which change from author to author.

Table 4. Literature survey about life-cycle GHG emissions and EROI values for different biodiesel feedstocks

Feedstock	GHG emissions g $CO_{2e}\ MJ_{biodiesel}^{-1}$	Reference	FER / EROI values $MJ_{biodiesel}\ MJ_{energy}^{-1}$	Reference
Rapeseed oil	80	Zah *et al.* 2007	EROI=3	Ecobilan, 2002
			EROI=1.78	Richards, 2000
			FER=2.15	Edwards *et al.* 2007
			FER=3	Lechón *et al.* 2009
Sunflower oil	30	Lechón *et al.* 2009	FER=2.75	Edwards *et al.* 2007
	27	Edwards *et al.* 2007	FER=4	Lechón *et al.* 2009
Palm oil	51	Lechón *et al.* 2009	EROI=9.6	Yusof, 2006
	45	Renew. Fuels Ag., 2008	FER=2.7	Lechón *et al.* 2009
	54	Zah *et al.* 2007		
Soybean oil	38	Lechón *et al.* 2009	EROI=2.48	Cavalett *et al.*, 2010
	60	Zah *et al.* 2007	FER=4.75	Lechón *et al.* 2009
Used cooking oil	11	Lechón *et al.* 2009	EROI=5.29	Rowe, 2008
	13	Renew. Fuels Ag., 2008	FER=20	Lechón *et al.* 2009
	31	Zah *et al.* 2007		

5. Conclusions

- Biodiesel produced from *Acrocomia totai* meets the sustainability criteria set in Directive 2009/28/EC (GHG emission saving higher than 35% among other criteria established in article 17) and could be approved for its commercialization in the EU, even beyond 2017 (when the saving value changes from 35% to 50%). Although the energy ratios are acceptable (EROI) or good (FER), some changes in the production will be necessary if the production volume boosts (i.e. the use of chemical solvents involving high emissions values due to the vast amount of energy used in their production), which would require a revision of all the environmental and energy ratios.
- Emission values are very favorable due to the boundaries taken. The particularly low emission value of Paraguayan electrical grid (0.4 g CO_{2e} MJ^{-1}) helps to obtain these low emission values. Also the use of current stands of *Acrocomia totai* helps in obtaining low emissions from the agricultural stage.
- Results are influenced by the quality and accuracy of the data used from respective databases with respect to reality in Paraguay. Developing specific databases with data from Paraguay and South America will improve the accuracy of the results of further LCA studies in this region.
- This LCA could be used as a starting point for the report that the EU requires to approve the *Acrocomia totai* biodiesel as a sustainable biofuel. Thereby *Acrocomia totai* could be added to the list of biofuels that are displayed in Directive 2009/28/EC.
- Total emission values for scenarios 1 and 2 are closer to the emission values of advanced biofuels than to the conventional biofuels (from oleaginous feedstock, such as soy, sunflower, palm, rapeseed…).

- Using a local feedstock is helpful to reduce emissions from transportation, as far as this feedstock has high oil content and good harvesting performance and the production process is efficient enough, although subjected to the attainment of a high-quality oil. These parameters are key points in choosing the feedstock.
- The energy supply of the extraction plant and the biodiesel production facility should use, as far as technologies are available, renewable energy sources with nil or close to zero emission factors, such as solar energy. But obviously the choice of the energy sources cannot endanger the reliability and availability of the energy supply.
- The feedback of the system using waste products from harvesting or co-products from extraction and production could maximize the use of renewable sources and minimize the amount of waste released to the environment.

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