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Characteristics of Jatropha Oil and Prospective for its Valorization as Feedstock for the Development of Biodiesel Technology in Guinea

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Abstract

The continuous depletion of fossil fuel and petroleum products, their limited resources and environment concerns are a matter of concern. The tendency in energy sector represents a challenge as well as an opportunity to look for alternatives of fossil fuels for sustainable development and environmental benefits. Study of biodiesel has become a key objective in the effort towards energy self-reliance. Since Jatropha oil cannot be used in the food industry, its use as energy source becomes very attractive. Before oil extraction, 1000-seed weight of Jatropha was investigated on the point of view of temperature and rainfalls. Seeds were grounded and defatted by extraction using a Soxhlet device. The lipid fraction of Jatropha oil seed were extracted and analyzed for their chemical composition and properties. The content of fatty acid in the extracted lipid was determined by use of Gas Chromatography (GC). Oleic acid (44.7%) and Oinoleic acid (32.8%) represent the dominant fatty acids while palmitic and stearic ones were the saturated fatty acids in the Jatropha oil. The crude oil from an average sample was transformed into biodiesel by transesterification in which a primary alcohol replaces glycerol from crude oil molecules.

Keywords: Energy, Jatropha, Environment, Climate oil, Transesterification, Biofuels, Acids.

Contents

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1. Introduction

As the most developing non-oil producing countries, Guinea imports the totality of oil and byproducts to cover its increasing energy needs. Owing to continuing exhaustion of known petroleum reserves and the impact of pollution and climate change, particularly the increasing of green gases emissions and the resulting climate change, it becomes a crucial necessity to develop alternative energy resources, such as biofuel. Nowadays security of energy supply, reduction of greenhouse gases, industrial wastes, and sustainable development are worldwide acknowledged as the most important drivers for biofuels. Goals for the development biofuels technologies have been set in several countries around the globe. The dominant points for the setting of such goals are potential contributions to energy security, mitigation of greenhouse effect and community development. Conversely, there is current and intense discussion over whether biofuels possess the capability of meeting these prospects. Specifically, the sustainability outline of biodiesels has been recently interrogated by several researchers. The furthermost and frequently cited questions of concern include biofuel direct and indirect impact on land use, general climate deregulation with several consequences such as: carbon stock decreases, depletion and pollution of water resources, biodiversity loss, and air quality degradation. In addition to these environmental problems, point to potential diverse conflicts resulting from energy versus food source antagonism.

The Life Cycle Assessment (LCA) methodology has been more and more used to evaluate the potential benefits and/or undesired side effects of biofuels. It investigates and considers the environmental flows related to a product or a service during all phases of the existence cycle.

Plant oil is a hopeful alternative because of several advantages, among others: its renewability, it is environment-friendly and can be produced easily in remote areas, where there is a severe necessity for modern forms of fuels. The domestication and development of shrub crops to serve as a dedicated and for the production of bioenergy, biofuels, and bio products can provide a long-term, sustainable substitute for fossil energy and boost rural development.

Several plant oils, including palm oil, soybean, sunflower, rapeseed, and canola oils have been used to manufacture biodiesel and lubricants [1]. The capability of Jatropha and other oil seeds bearing plants to produce clean energy, to restore poor or dry lands, from which the rural population mostly grows its sustenance, makes it a promising multipurpose crop. In Gui nea Jatropha grows in a wide range of climatic conditions which are particularly suitable in the country. The average rainfalls vary between 3800 mm on the coast and 1240 mm in Upper Guinea where it represents the most planted tree.

The technology of producing renewable energy sources from biomass holds the potential of creating in-house energy resources while lowering the emission of greenhouse gasses.

Biofuel is usually manufactured by a transesterification reaction of plant oil with a low molecular weight alcohol. It is monoalkylesters of fatty acids resulting from plant oils or animal fats; it is relatively clean and renewable. Biofuel is usually produced by the transesterification of vegetable oils fats with methanol or ethanol [2].

Biodiesel has several benefits include the following: renewability, safety for use in diesel engines, performance and engine durability as petroleum diesel fuel, non-flammable, reduces gazes emissions, and other noxious smokes and emanations.

2. Background

2.1. Depletion of Fossil Energy Resources

In a period of two centuries the oil reserves synthetized by the nature during paleontological eras are almost used up. Photosynthesis is a process in which green plants convert solar radiation into chemical energy in the form of hydrocarbons. Fossil fuels result from dead animals and plants buried in geological layers in paleontological eras. Biofuels are processed from plants of our time which can be grown from season to season depending on the plant species and varieties. What the interaction between mineral rocks and organic matter provided us as *petra-oleum* (petroleum) is finite and the time has come to switch to vegetable oil *phyton-oleum* that soil and plant offer every year. A quiet new word "*phytoleum"* refers to the biofuel as renewable source of energy.

The exhaustion of petroleum reserves and uncertain petroleum market due to various crises, and environmental concerns can promote vegetable oils. Since the 70's energy crisis, fossil fuel becomes more and more expensive followed by a pollution increment, the need to promote alternative energy resources becomes more evident.

No other sector of activity requires sustainability as the energy supply and use. The modern world learned so fast to use fossil fuel that the reserves cannot meet the needs of near generations. For instance about 17 billion barrels of oil had been dig out worldwide by 1930. Over 17 billion barrels of oil were being extracted each year by 1970. As of 1997, 807 billion barrels of crude oil had been extracted from the Earth's crust and 995 billion barrels remained which could be extracted at current production costs. If the world ratio of consumption remained unchanged at the current amount, the known oil reserves will be exhausted in 2040. Demand for oil will overshoot supply well before 2040 [3]. At this increment rate, the fuel supply cannot be afforded in developing countries.

2.2. Outlook for Energy in Guinea

Guinea's energy requirements are covered by a combination of electricity, biomass and petroleum. The contribution of biomass in the consumption is dominant, that of electricity is insignificant In Guinea less than 10% of the population use electricity (Fig.1). The total consumption amounted 0.775 TWh in which fossil fuels represented 46.45%. The electric power amount and the total energy use per capita remain insignificant. At the present time firewood and charcoal are the main energy source for population [4].

Till May 2015, the installed capacity in Guinea was about 225MW; since the launching of the Kaleta hydro-plant with 240 MW, the total capacity has reached 465 MW to which thermic and hydroelectricity represents 45% and 55% respectively. Investment in the energy production is crucial because demand will rise sharply as mining activities and wider economic growth pick up. Projections show mining sector demand alone rising sharply from

80MW in 2010 to more than 500MW and 600MW by 2015 and 2020 respectively; while domestic demand is projected to reach 1100MW.

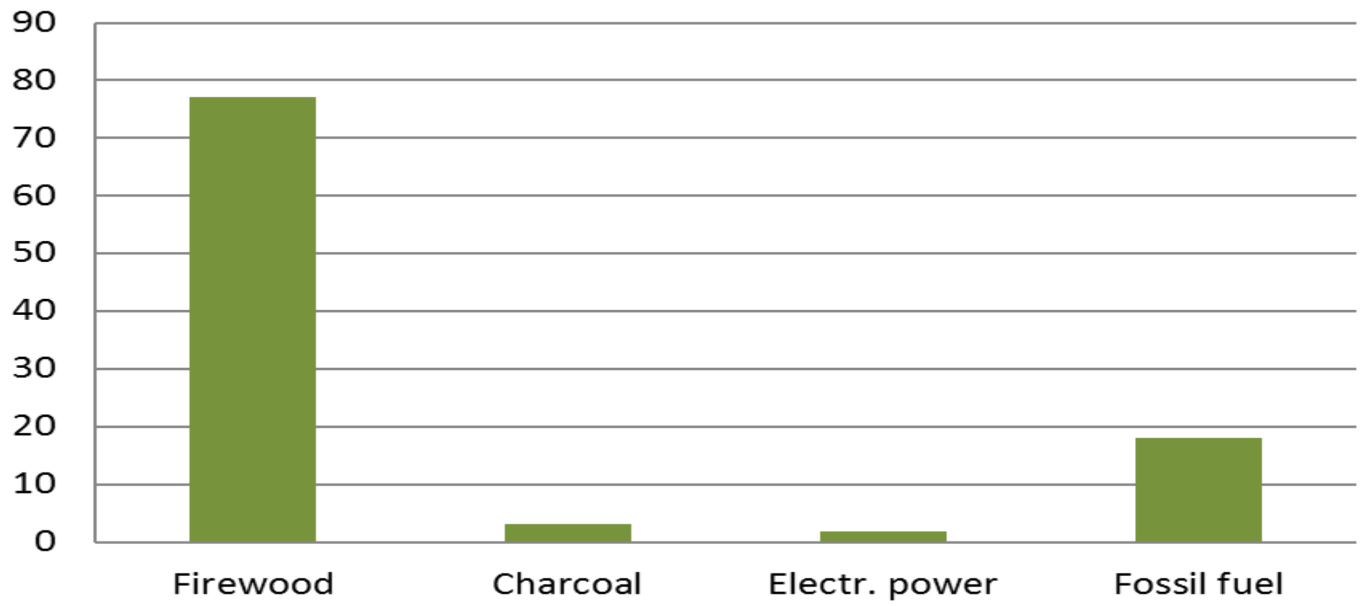

Fig-1. Energy shapes consumption in Guinea

Sources: USA Department of Energy; Energy Information Administration /Office for Fossil Energy 2002

The potential for the country to become a regional power supplier is unlikely to be realized in the country the biggest new hydropower producer the Kaleta Dam has a capacity of 225 MW. The second hydropower Garafiri dam is in bad repair and operates much below its nominal capacity. Countrywide, electricity supply is below 100MW, and generation can be as low as 30MW, so that the Government is constrained to expensive emergency solutions. Outside the capital city Conakry, micro hydropower dams continue to supply power only because of the ingenuity and know-how of Guinean engineers and technicians.

In Guinea the biomass resource is huge and essentially based on firewood energy. In spite of the high predominance of wood and charcoal in the energy balance in Guinea, the actual potential of the country remains unknown. Basing on various estimations, the accessible volume varies from 8.5 to 14 million m3. Presently, about 92 biogas plants are installed.

Because of the insignificant use of modern energy resources, firewood and charcoal are the main fuels used by households. About 80% of households have access to firewood and about one fifth can obtain charcoal.
Petroleum products consumed in Guinea are imported; imports were 692,286 metric tons in 2005, compared with 727,820 metric tons in 2004.

In spite of its huge and varied underground resources, Guinea imports the totality of fuel to cover its needs as shows Table 1. It is sure that the oil import expenses will continue to be an enormous problem on the country's balance of payments. Hence energy security has become a strategic issue for decision makers.

Table-1. State of Energy in Guinea

Power source	**Indicators**	**Values**	**Dates**
Electricity	Access to electric power	7%	(2002; 02-01)
	Consumption	0,721 TWh	(2003 ; 00)
	Consumption per capita	41 kWh/an	(2003 ; 00)
Petroleum	Consumption	8 210 barils/day	(2003 ; 00)
	Production	0 barils/day	(2003 ; 00)
	Export	0 barils/day	(2003 ; 00)
	Import	8 210 barils/day	(2003 ; 00)

Sources: USA Department of Energy; Energy Information Administration /Office for Fossil Energy 2002

2.3. Jatropha Curcas Oil

However Guinea as other countries in tropical regions enjoys abundant sunlight that can generate both electric and thermic power. But such a technology requires sizeable investments. Looking for alternates sources to replace petroleum based fuel becomes a challenge.

As concept, sustainability is founded on the integration of three dimensions: the ecological, the economic and the socio-cultural dimension. The activities of the society today should therefore be grounded on the goal that the development of coming generations has the same if not greater potential as today. For illustration, the use of present resources by today's societies should not lead to scarcities for forthcoming generations. In this context, besides the degree of use and the proposed handiness of natural resources also the demographic development and technological innovation potentials represent central parameters to take into account for an efficient prognosis of a sustainable development [5].

In the energy sector sustainability means to secure an economically renewable clean supply, protect soil and climate and provide social development. As renewable energy resource Jatropha oil meets these goals. The handiness and sustainability of important quantities of relatively cheap feedstock will be an essential factor supplying competitive biodiesel products. Opportunely, non-edible plant oils, generally produced by seed-bearing plants represent quiet interesting substitute. Since there is no conflict food versus fuel , this characteristic offers much attention to Jatropha curcas, a shrub growing in tropical and subtropical climates across the third world [6].

Jatropha curcas is a shrub belonging to the family of Euphorbiaceae. As a plant it is characterized by many properties, attributes, manifold uses and extensive potential. Jatropha can be used to prevent land degradation and to control erosion. The plant is grown as a live fence, particularly to exclude farm animals and be cultivated as a marketable agricultural product. It is a native of Mexico; nowadays, Jatropha prospers in many parts of the tropics and sub-tropics. [7]

The Jatropha as crop draws the attention due to the multipurpose potential of its oil and other derivatives. The seed contain about 35% oil (Fig.2). With regard to oil content, the Jatropha seed represents one of the richest small seed (Fig.2). Habitually the seeds are harvested from live fences surrounding crop fields in rural localities. It represents a unique vegetable among renewable energy sources in terms of the sum of benefits that can outcome from its cultivation [8].

However *Jatropha* remains an undomesticated plant that requires significant agronomic advances to fulfill expectations resulting from the publicity that has been engendered over the several years worldwide [9]. Some researchers claim to be making progress towards higher yielding, homogenous, drought-resistant varieties, although the results of such research remain available only at the experimental level, especially for smallholder farmers in very specific areas or localities. It is still not clearly defined the period of time required for such efforts to be realized. But until such time, and taking into account the findings from our fieldwork and subsequent analysis; it is recommend that Jatropha should not be promoted among smallholder farmers as a monoculture or intercropped plantation crop.

Fig-2. GTZ – Regional Energy Advisory Platform East Africa [10]: Jatropha oil
Source: www.worldagroforestry.org/downloads/Publications/PDFS/B16599.pdf

2.4. Biofuels

In a broad sense, biofuel defines relatively pure and chemically processed vegetable oils or animal fats. It is mono-alkylated esters of fatty acids and is known as a clean and renewable fuel. It is usually produced by the transesterification of oil or fat with a primary alcohol mainly methanol or ethanol. The advantages of biofuel are multiple. Among others: its renewability, safety for use diesel machines, its performance and durability as petroleum diesel, non-flammability and nontoxicity, reduced emissions, etc. Biodiesel use has grown intensely during the last decades. The main factor influencing the biodiesel production is the feedstock cost. It accounts for a large percent of the direct biodiesel production expenditures together with capital and return. The chemical composition of these oils is a mixture of several compounds such as triglycerides, free fatty acids, sterols, water, odorants and other impurities. Presently biofuels are manufactured from a number of crops: Jatropha, rapeseed, soybean and sunflower, palm oil.

There are as many different biodiesels as different oil compositions. Depending on climate and soil conditions, the content and saturation of oilseed species and varieties differ significantly. The properties of the resulting biofuel are strongly by these characteristics. Many properties such as the boiling and melting points of the main compounds of biofuels : fatty acids, methyl esters and glycerides rise with the increase of carbon atoms in the carbon chain, inversely, they decline with an increasing of double bonds in the molecules [11]. Fatty acids with simple bounds are greatly compactable, which improves the oil energy density. With a great content of saturated fatty acids, oils and fats become solid at room temperature and cannot be used as fuel except in warm climates. The weaknesses of plant oils are their higher viscosity, lower volatility and the reactivity of unsaturated hydrocarbon chains [12].
Because of ensuing difficulties such as carbon deposits in motors, machine durability, ete, they must be chemically converted to be well-suited and utilizable on a long period.

!!!!!!The prevalent biofuels are methyl esters as products of the chemical reaction of plant oils with a primary alcohol such as methanol. Other methods based on micro-emulsion and pyrolysis; they are not widely used; pyrolysis particularly is costly for modest quantities. For the transesterification process i.e. the alkali-catalyzed reaction, 107.5 kg of methanol is required to convert 1 ton of plant oil and a production of 1004.5 kg and 103 kg of methyl ester and glycerol respectively is obtained [13]. In this reaction, triglycerides are converted into diglycerides, then monoglycerides and finally reduced to fatty acid esters, enhancing the viscosity of the final biodiesel. Viscosity of plant oils is 10-20 times greater than that of their resulting esters and twice that of diesel fuel. In order to reduce the amount of impurities such as free fatty acids and water and to improve the reaction kinetics a pre-step and catalysis are required. Because of its physical, chemical properties and cost, methanol is preferred over ethanol.

In Guinea the Jatropha oil is usually used for soap production and as fuel in special lamps for lightning. As shrub *Jatropha curcas* remains also one of the main planted in Upper Guinea as a life fence [5].

The climate prevailing in Guinea seems to be particularly suitable for the production of this crop (Tab. 2). High yields could be reached at 2000 m altitude in Cap Verde.

A collection of several provenances in multi-location trials in Cap Verde and Senegal in the Sahel region was tested [14]. The investigation revealed a strong interaction between climatic factors and plant performances for all parameters, meaning that environment exerts a specific influence on provenances.

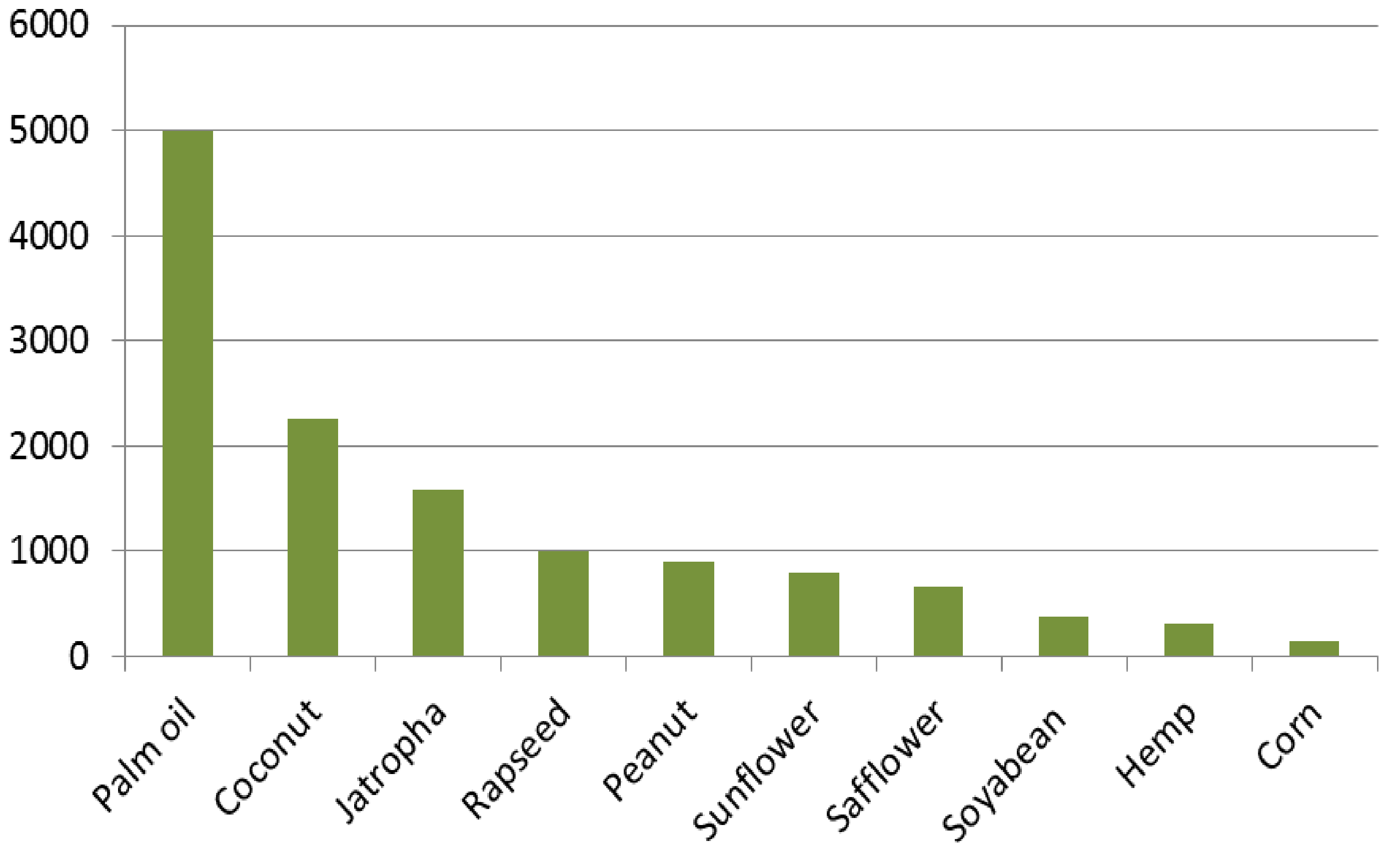

Fig-3. Vegetable oil yield (Kg/ha)

Source: Our own results

Table-2. Altitude (m) and rainfalls (mm) in seed provenances

Provenances	Altitudes (m)	Rainfalls (m)		
		2005	2006	20007
Conakry	121,439	4300,1	3800,8	3562,9
Mali	1462,25	1161,1	1107,4	1208,1
Dabola	423,054	1249,0	1520,5	1519,4
Dinguiraye	465,62	1209,0	1359,1	1556,2
Faranah	451,39	1566,3	1709,6	N.A.
Kankan	471,43	1236,2	1454,5	1344,2
Siguiri	420,62	1236,2	1352,4	1094,2

Source: Service National de la Météorologie; Conakry

2.5. Climate Change and Greenhouse Gas Emission Tendencies

Latterly biofuels have been promoted worldwide in a twofold framework of energy uncertainty and climate change. Except for a few special cases, wide attention was paid to biofuels as real potential energy sources, only after convincing proofs and the consciousness of the hazards associated with the use and the exhaustion of fossil energy. Since the conclusions of the Intergovernmental Panel on Climate Change (IPC) at the end of 1980s, on the veracity of climate change and the impact of greenhouse gas emissions, the more concrete the international strategies and instruments to promote renewable energy resources have appeared.

Needs for action and cooperation have been expressed within the framework of international agreements; such as the United Nation Framework Convention on Climate Change in 1992 and the Kyoto Protocol in 1992 and 1997 Although they might not have federated enough stakeholders, notably the Kyoto Protocol which only came into application in 2005 without certain of the main CO2 providers, they gave way to the establishment of effective frameworks and national action plans.

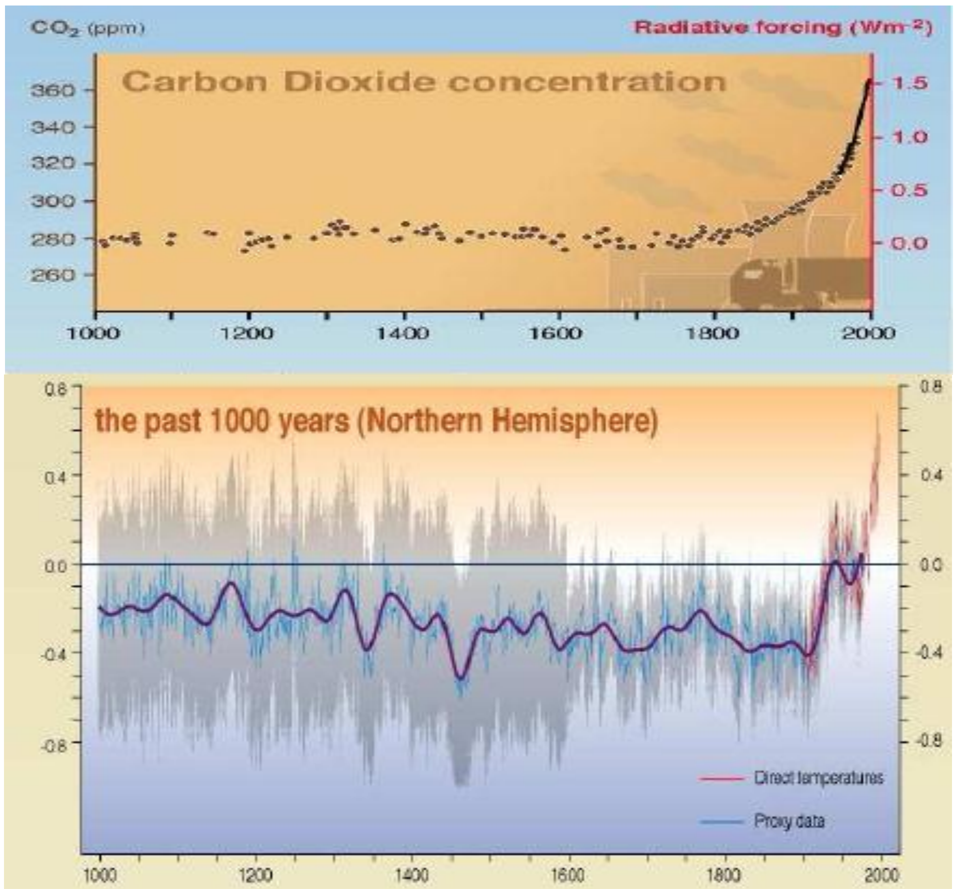

Fig-4. CO2 Concentration in the period 1000-2000

Source: United States environmental protection Agency (EPA)

Fig.4 illustrates the emission trend of CO2 in the atmosphere since the year 1000 of this era. The global average surface temperature on the Earth increased about 0.7 ◦C between the late 1800s and 2000, with a rate of about 0.2 ◦C per decade [15] in the past three decades. However, taking into account the effects of orbital variations on climate, absence of anthropogenic impact, the natural trend would be toward a cooler climate, as was the peak warmth of the interglacial period (Holocene) that occurred 8–10 thousand years ago. Analysis of prior interglacial periods reveals a strong relationship between the CO2 and CH4 concentrations in the atmosphere and temperature records.

Nevertheless, in the past the temperature changes usually preceded the changes in gas concentrations. At present, anthropogenic greenhouse gas emissions are overpowering and reversing the order in the way that greenhouse gases are driving temperature increases. The climate scheme has not come to balance with present climate forcing therefore more warming should be expected. Nowadays humans survey overall climate, for better or worse [16]. It means that since the mid-20th century most of the perceived rise in global average temperatures is very likely due to the correlated increase in anthropogenic greenhouse gas amounts. Obvious anthropogenic effects now spread to other aspects of climate such as ocean warming, continental-average temperatures, temperature extremes and wind patterns [15]. Pre-industrial total concentrations of the main greenhouse gases: CO2, N2O and CH4, have increased significantly as a result of anthropogenic activities. Nowadays they exceed far pre-industrial values determined from ice cores covering many thousands of centuries.

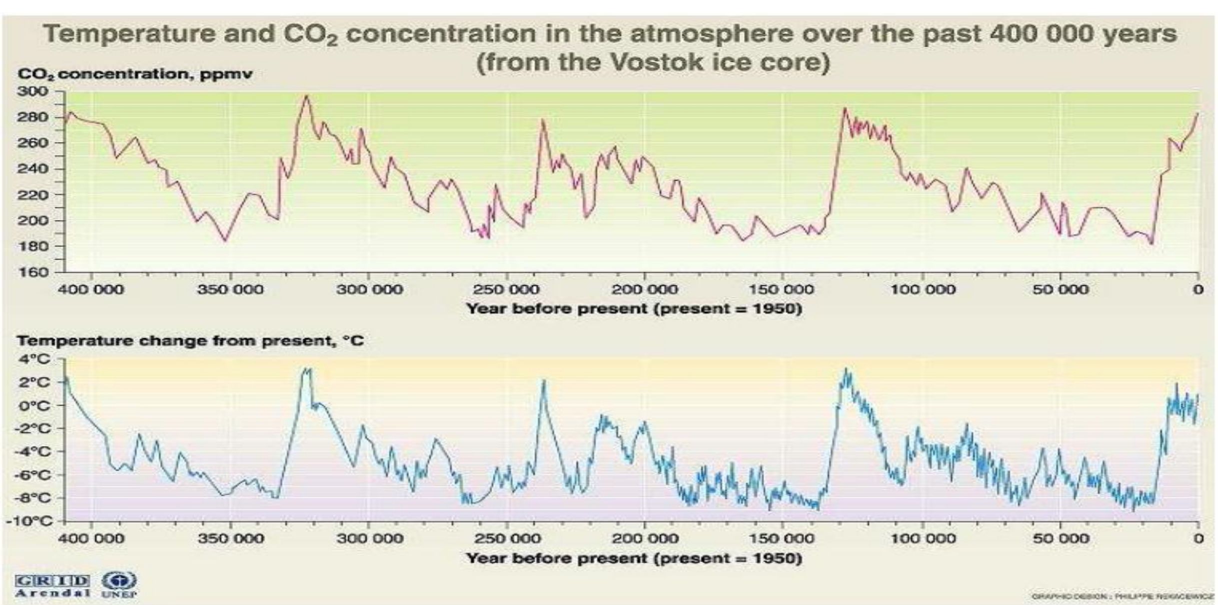

Fig-5. Temperature and CO2 concentration in the air over the past 400 000 years

Source: Petit and Jouzel [17]

Overall increases in CO_2 concentration are due mostly to intensive use of petroleum-based fuel and land-use change whereas those of CH4 and N2O are chiefly due to agricultural inputs such as nitrogen fertilizers. If CO2 emissions continue to increase by 1.5 to 2% per year, doubled CO2 will be reached in approximately the year 2050.

Taking into account the whole range of the IPCC emission scenarios, from the lowest to the highest emissions, global warming could reach 1.8 to 4 ◦C by 2100 [15]. A global warming of 2 to 3 ◦C over the pre-industrial temperature would already "make the Earth a different planet" [16].

As a very critical issue, sea level rise demonstrates how climate change can lead to exponential and irremediable impacts due to accumulation phenomena. IPCC scenarios give estimations of a sea level rise between 38 cm and 59 cm by the end of the 21st century compared to the period 1980–1999. This is due mostly to thermal expansion; the rapid changes in ice flow are not taken into account. There is still not a fixed and precise statement on the long-term future of the ice sheet or its contribution to sea level rise. It is not possible to say how long it would take for sea level to change since the recordings and feedbacks can lead to highly non-linear responses. Nevertheless it is certain that under the present scenario, climate change would yield a sea level change of the order of meters on the century timescale. Basing on the populations in 2000, a sea level rise of 6 m would displace 35 million inhabitants throughout the world and trouble is brewing for many species.

The distance that climate zones have moved from a geographic point to another due to changes so far is small. But the rate of movement of isotherms is now pole-ward at 50 km per decade and will double this century if anthropogenic impact continues with the same intensity.

2.6. Biofuel Greenhouse Gas Balances

Most studies have found that the consumption of first generation biofuels results in emission reductions of 20 to 60% of CO2eq compared to fossil fuels. Expected reductions for future commercialized second generation biodiesels are in the range of 70 to 90% of CO2eq [18]. The significant reductions of CO2 and NOx emission for the first generation biofuels is due to various types of feedstock and conversion processes, and to the different sites of production and consumption.

Life Cycle Assessment methods and assumptions also contribute to explain that greenhouse gas balances of a given biofuel chain in one region may be variable. Finally, field emissions in particular are complex to assess and imply further disparities amongst studies. Greenhouse gas mitigation or reduction therefore represents ranges; it does not make much sense to give a list of mean values for every biofuel chain.

A sensitive analysis of the N2O emission factors showed that these assumptions strongly influence the balance. Greenhouse gas emissions rise from 40 to 50% for methyl esters and plant oils by using Bouwman's IPCC emission factors instead of those from Skiba, et al. [19]. The resulting greenhouse gas reduction falls, for instance, to -55.5% and -66% for the rapeseed pure oil and methyl ester, respectively. Although Bouwman's factors may be more accurate because the regression was based on more data sets on a broader range of soil diversity, whereas Skiba's factors were established for the UK's soils. Extrapolation from any linear model implies a high uncertainty on the results due to the site- and time-dependence of field emissions. N2O emissions in the JRC/EUCAR/CONCAWE study are likely to be more accurate as they were simulated with the DNDC model (version 82N) combined with the LUCAS land-cover survey model. The resulting emission factors, moreover, include N2O indirect emissions from leached N. However, as the study assessed biofuel chains at the European level, the simulations were performed to determine new emission factors through regression models. The averaged crop emission factors finally hardly give an approximate of total N2O emissions at a national level, while emissions are too variable on such a scale to help distinguish between biofuel chains and co-product options at the limited geographic level. Nevertheless, biofuel chains with a valued coproduct lead to save a lot of greenhouse gases, especially if biomass production is optimized to reduce field gases emissions as much as possible.

3. Material and Methods

Jatropha seeds were harvested from live fences with no specific treatments such as soil cultivation, irrigation, fertilization, pests or diseases control, etc. The provenances are mainly located on the Coast region and in Upper Guinea. The 1000-seed weight was determined with a Soenle S20-2760 balance. The seeds were selected according to their condition where damaged seeds were discarded before seeds in good condition were cleaned; the investigations were performed on the kernel dried at temperature about 100^{o}C for 1 hour. Seeds were grounded using grinder and defatted in a Soxhlet system; the crude oil was extracted using hexane. The extracted oil was filtered and the solvent was removed with a rotary evaporator apparatus at 50^{o}C.

Oil colour was assessed on organoleptic basis. Densities and refraction index were determined at 25^{o}C with a portable Mettler Toledo densimeter and the refractometer Kruss. Hannus-method and neutralisation are used to determine iodine value and acid value respectively. The saponification value was determined according to MPOB Test Method.

Mainly biodiesel is produced by transesterification i.e. by the chemical approach, a well-developed technology worldwide. Alkaline-catalyzed transesterification is the most common method whereby sodium hydroxide (NaOH), potassium hydroxide (KOH) and sodium methoxide (CH3ONa) represent the most alkali (base) catalysts. As catalyst CH3ONa is more effective than NaOH and KOH but it is more expensive. Base catalysts are sensitive to water and free fatty acids. When sodium methoxide is used, its weight ratio is 0.3-0.5% of the weight of the oil. When NaOH or KOH is used, a higher amount of catalyst: 0.5 to 1.5% is required. As catalysts NaOH and KOH cause water formation, slow the reaction rate and lead to soap formation. CH3OH is the most primary alcohol used for transformation of fats and oils to biodiesel. It is flammable, and safety measures are required. Since the process is a reversible reaction, extra methanol or ethanol is required in order to drive the reaction forward to increase the yield of the alkyl esters and to make easier phase separation from the glycerol. In the process methanol and alkaline catalyst sodium hydroxide (NaOH) was chosen respectively as solvent and alkali catalyst because they are cheaper and reacts much faster.

The mass of *Jatropha* oil molecule is 870g; after extraction the oil contains additional minor constituents, therefore the approximate molecular weight was taken as 900. For the reaction, 3 moles of methanol are necessary to react with 1 mole of vegetable oil. The molecular weight of methanol being 32 and hence 96 g of methanol were required for the conversion of 1 mole (or 900 g) of oil, which corresponds to 10.67 % methanol.

The oil is slightly warmed before addition of methanol and catalyst. The NaOH pellets was gradually dissolved in methanol and stirred to obtain a sodium methoxide solution which was gradually added into the crude oil; the mixture was sired. Methanol and oil do not mix well and vigorous mixing at the beginning of the reaction improves reaction rates. Nearby the end of the reaction, reduced mixing allows the separation of glycerol. The reaction is usually conducted below the boiling point of methanol (60°C) and it may last 30 to 90 min. The final product is taken into a separating funnel in which two phases are distinct after few minutes: a golden yellow liquid representing the biodiesel on top and the glycerol at the bottom. Gas Chromatography and Mass Spectroscopy were used to to characterize the properties.

A key threshold for considering the valorization of a vegetable oil as biofuel is the chemical and physical characteristics of the oil. Viscosity, iodine number, carbon residue, saponification number, and other parameters determine the oil's suitability for conversion to biodiesel. Fatty acid composition was determined by Agilent 6890 series gas chromatography (GC) with flame ionization detector and capillary column.

The oxidation stability test in was carried out by a Rancimat Model 743 following the EN 14112 method. Each 3 g of biodiesel sample is aging at 110°C with 10 l/h airflow rate.

4. Results and Discussion

The optimal agronomy of developing Jatropha as a plantation crop, instead of as a minor component of an agroforestry scheme, is still not well determinate or documented. Recent observations of plantations across developing regions confirm that *Jatropha curcas* may endure low precipitation about 300 mm, but will not produce significant quantities of seeds at those levels. Nowadays there are several data and information about agronomic parameters within which *Jatropha* will grow and thrive. But very little is known about what conditions are actually optimal for obtaining the highest yields [10, 20, 21].

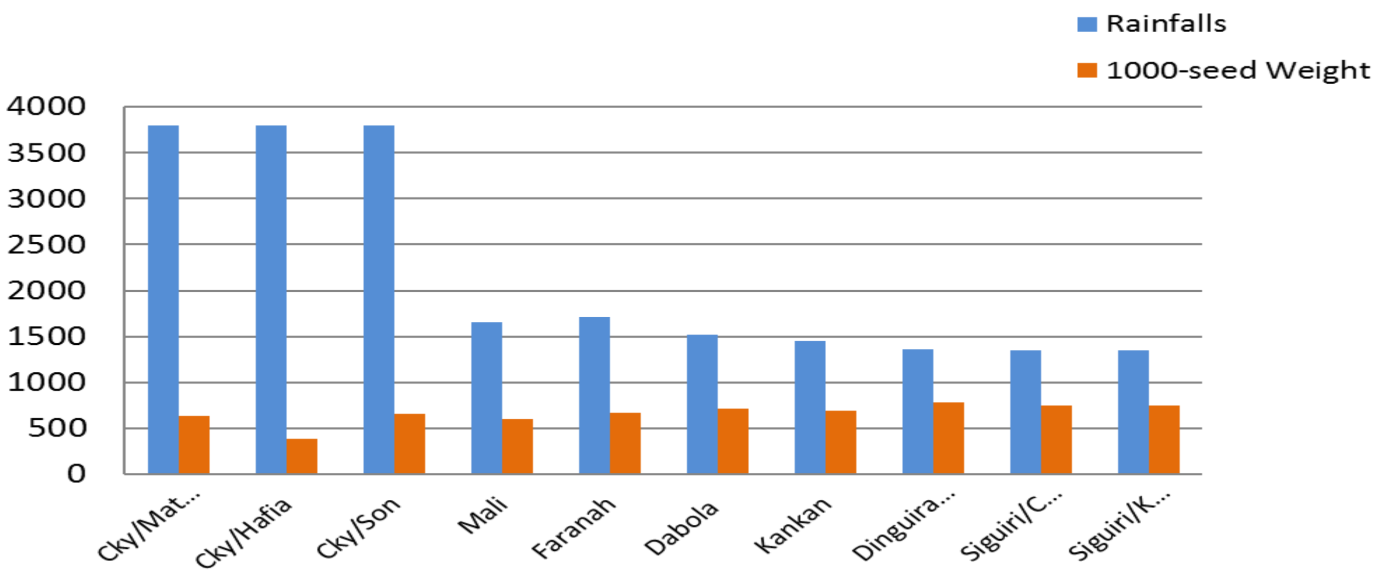

Fig-6. Effect of rainfalls on 1000-seed weight

Source: Our own results

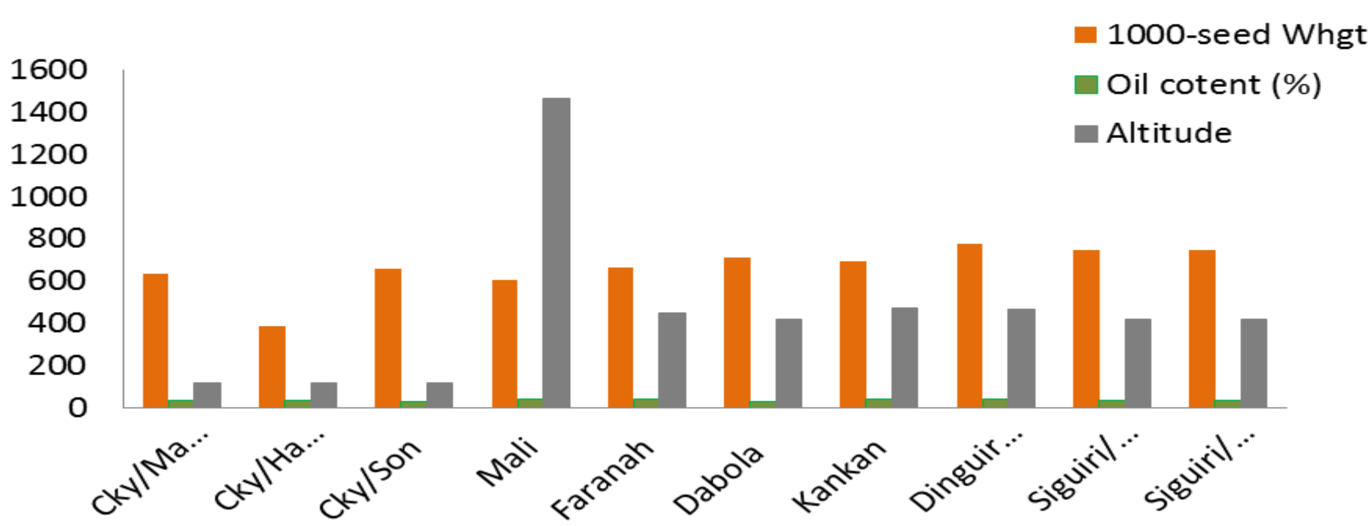

Fig-7. 1000 seed-weigt (g), oil content as function of altitude (m)

Source: Our own results

As for 1000 seed-weight, Fig.6 shows that the heavy rainfalls prevailing on the Coast and probably the low altitude (Conakry) correlate negatively with the 1000 seed-weight. The 1000 seed-weight are greater in regions with fewer or lower rainfalls: 779g, 748g and 709g for 1000 seeds from Dinguiraye, Siguiri and Dabola respectively.

Basic investigations of soil properties should contribute to better results and statements. Nevertheless the 3 samples collected from Conakry showing lower seed weight come from quite distant points.

Fig.7 shows that basically altitude of a given area does not impact significantly the 1000 seeds-weight and the oil content of seeds (%).

The tranesterification did impact the ratios of the different acids of seed. Fig.4 shows the relationships between oil content, 1000 seed-weight and the topographic altitudes of the provenances. It appears that a high oil content of the seed correspond to greater values of 1000 seed-weight. Low altitude on the Coast seems to result with lower seed weight. This confirms the results of trials [10] indicating a significant correlation between the 1000-seed weight and oil content. This may represent one of selection elements, if genotypes exist where these are combined with high yields. On the basis of this investigation it looks that no perceptible interaction exists between the rainfalls and the oil content.

Oil content in the seeds is relatively high with an average of 35% [21-25]. The oil content in seed samples from different provenances in Guinea shows a value of about 40%. It exceeds 40% in four samples of a total of eleven. Excepting the sample from Conakry (Sonfonia) and Dabola with 32.5 and 32.6% respectively no sample contains less than 37%. Four samples contain 40% at least. The last two lines of table 3 represent the characteristics of *Moringa oleifera* and *Carapa procera* oil. The Moringa oil is renowned for its multipurpose use. Nevertheless the Jatropha seed contains twice more oil with close physicochemical properties. Generally more oil was found in seeds originating from dryer areas. High oil content of *Jatropha* oil as non-edible makes it a suitable feedstock in chemical industries: biodiesel, fatty acids, soap, fatty, nitrogenous derivatives, etc.

Basic properties such as density, acid and iodine number, saponification value, are in the limits of crude Jatropha oil properties. Other properties such as refraction index, acid value, iodine value are in the limit of Jatropha oil characteristics from several reports [26-30].

Table-3. Physicochemical properties of Jatropha crude oil

Provenance	Seed (g)	Oil (g)	Oil (%)	Iodine value	Refr. Index	Density	Acid nber	Sapo. nber	Unsapon.	Hygros. (%)
Dabola	76,40	24,50	32,06	26,01	1,4699	0,955	0,86	70,34	0,02	0,34
Dinguiraye	87,70	39,55	45,09	24,50	1,4785	0,933	0,88	71,31	0,06	0,46
Faranah	81,90	33,75	40,13	30,10	1,4693	0,956	0,77	66,33	0,04	0,33
Kankan	83,50	35,35	42,33	20,50	1,4555	0,946	0,68	75,69	0,07	0,66
Mali	84,10	35,19	41,84	19,90	1,4596	0,934	0,66	76,57	0,03	0,44
Conakry/M	76,60	28,45	37,14	20,20	1,4485	0,942	0,76	76,36	0,09	0,37
Coakry/H	97,72	37,89	38,77	80,05	1,4922	0,89	1,87	184,52	0,97	3,4
Coakry/S	56,70	19,99	35,25	78,49	1,4919	0,91	1,73	183,15	1,05	3,6
Siguiri/K	217,31	81,15	37,34	59,95	1,4517	0,95	1,83	185,16	0,98	3,5
Siguiri/C	104,57	38,74	37,04	74,49	1,4874	0,78	1,78	182,25	1,02	3,2
C. procera	*46,40*	*10,45*	*22,52*	*25,10*	*1,4865*	*0,966*	*0,87*	*71,60*	*0,01*	*0,56*
M.oleifera	*22,70*	*5,25*	*17,67*	*22,80*	*1,4574*	*0,922*	*0,64*	*73,52*	*0,08*	*0,58*

Source: Our own results

The iodine value is a parameter indicating the unsaturation of fats and oils. Higher iodine value shows a higher unsaturation level of the acid such as oleic and linoleic ones. A lesser amount of amount of unsaturated fatty acids could be an ideal characteristic since heating unsaturated fatty acids at higher temperature results in polymerization of glycerides [6]. This can cause formation of deposits. Fuels with this characteristic tend to produce thick sludge in the sump of the motor, when fuel seeps down the sides of the cylinder into crankcase.

The iodine value\ of *Jatropha* oil ranges it in the semi-drying oil group. *Jatropha* oil consists of about 78.5% unsaturated fatty acid (Table 3). High saponification value indicated that oils are triglycerides and very suitable for the production of liquid soap and shampoo industries. Table 4 shows a free fatty acid content of 3.1and 0.25 % for the oil and the biofuel respectively. The free fatty acid and moisture contents have significant effects on the transesterification. A high free fatty acid content (>1%) will lead to soap formation and the separation of products will be exceedingly difficult and result with a low yield of biodiesel product. The acid-catalyzed transesterification is an alternative, but it is much slower than the base-catalyzed one.

Viscosity is defined as resistance liquid to flow. It increases with molecular weight but decreased with increasing unsaturated level and temperature [31]. The viscosity of Jatropha oil is too high and must be reduced for biodiesel application. High viscosity of the Jatropha oil is not suitable for its use directly as engine fuel. Frequently it results in operative difficulties such as carbon deposits, oil ring sticking, and thickening and gelling of lubricating oil. These problems results of contamination by the vegetable oils. There are several methods to decrease the oil viscosity and make it fit for engine applications. Among others: preheating, blending, ultrasonically and/or supercritical methanol transesterification. Our investigation shows that after transesterification the kinematic viscosity of the crude oil decreased about 82%. The specific gravity of the investigated samples is slightly inferior to the EN (European Norm) diesel quality but much closed to that of its biodiesel.

The viscosity of vegetable oils and that of the resulting esters is of the order of 10–20 times; [12] catalysis make it possible to deal with the impurities such as free fatty acids and water to improve the reaction kinetics [11]. Methanol is preferred over ethanol because of its physical and chemical properties as well as comparative low cost. For different esters from the same vegetable oil, methyl esters also appeared to be the most volatile ones.

The density of is defined as the measured of its mass per unit volume (e.g. in g/ml). The density of vegetable oil is lower than that of water and the differences between vegetables oil densities are quite small. Generally, the density of oil decreases with molecular weight and it increases with unsaturation level. The density of investigated oil samples varied from 0.78317 to 0.955.

Table-4. Physicochemical properties

Parameter	EN-diesel	EN-biodiesel	Crude oil	Transest.biod
Colour	Gold. yellow	Gold. yellow	Gold. yellow	Gold yellow
Kinematic viscosity mm^2/s	2,0-4,5	3,5-5	27,11	4,8
Specific gravity	0,82-0,845	0,86-0,90	0,92	0,87
Free fatty acid			3,1	0,25
Acid value (mgKOH/g sample)		0,50	6,3	0,49

Source: Our own results

The composition and the properties of the triglyceride and the biodiesel are determined quantitatively and qualitatively by the amount of fatty acids in the molecules. While chain length and number of double bonds determine the physic and chemical characteristics of both fatty acids and triglycerides [32]. Transesterification does not modify the fatty acid composition of the oil and this composition plays an important role in some critical parameters of the biodiesel properties as: specific gravity, free fatty acids and acid value (Table.4).

Biodiesel can be added to diesel in order to improve its lubricity. This property becomes increasingly valuable as recent legislation has mandated further regulation on the sulphur content of diesel fuels. These cleaner diesel fuels exhibit reduced lubricity as compared high sulphur containing fuels predecessors. The co-products of the entire chain are the meal left in the seed after oil extraction, which is sold as animal feed, and the glycerin from glycerol recovery, used in cosmetics.

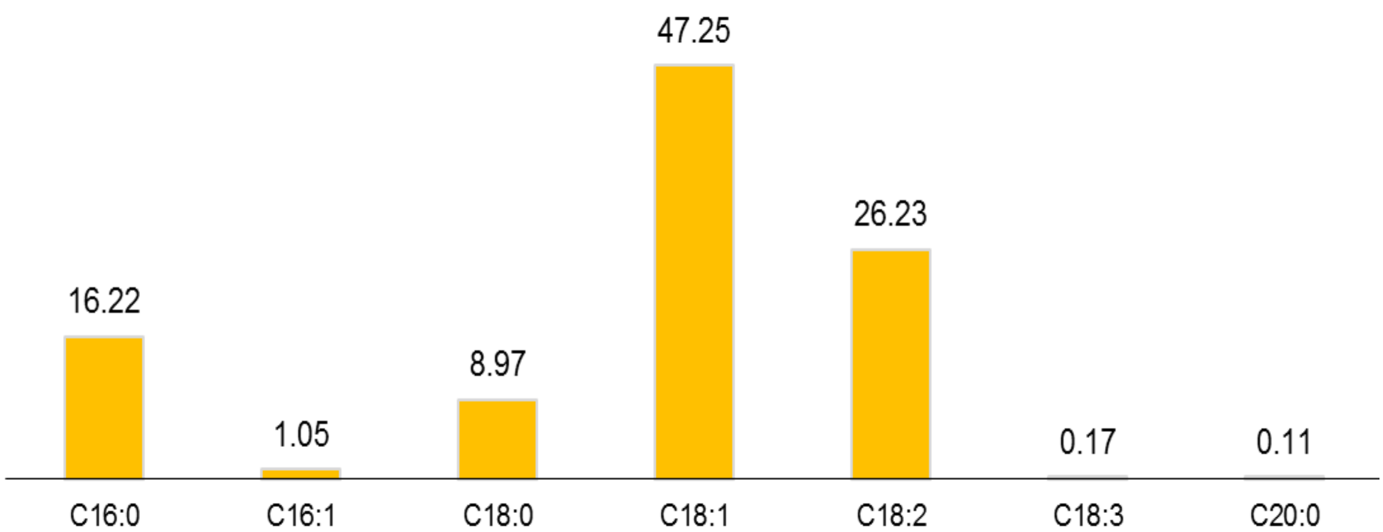

Fig.7. Fatty acids content in tranaesterified Jatropha oil (%)

Source: Our own results

Fig.7 illustrates the nature and amount of fatty acid (C16-C20) in biofuel. It shows the presence of palmitic 16%; stearic 8.97%; unsaturated stearic 47%; linoleic; 26.23% acid molecules respectively.

!!!!! The oxidation test shows that the stability to oxidation as a key property of biofuel depends on the fatty acid composition. Biofuel from Jatropha oil, with a high content of unsaturated fatty acid has a relatively short induction periods about 6 hours.

The stability of such oil to oxidation is not meeting the European standard. Transesterified Jatropha oil is unstable and easily oxidized in presence of air. The chemical changes that take place in transesterified Jatropha oil are due to the oxidation process produce hydroperoxides as primary products [10] which are very unstable. Hydroperoxides were cleaved and resulted in the formation of secondary products such as shorter chain fatty acid, aldehydes, ketone, hydrocarbons and alcohol. Some of the compounds resulting from the oxidation process have acidic properties which may give negative effect on fuel quality consequently in engine corrosion.

5. Conclusion

Although bioenergy and biofuels in particular have recently been high on the policy agenda and subject to a lot of discussion, they still only contribute a marginal share in the worldwide energy production. Some key points may help to figure out how bioenergy can play a bigger part in the years to come.

When reviewing biomass potential assessments, a rather modest assumption would be that the share of bioenergy in the whole energy use can be multiplied by a minimum factor of 2.5, but such deployment scenarios are extremely hard to predict since technology evolution is nonlinear. This means breakthroughs may be expected with the time, notwithstanding the driving role of policies that are also constantly evolving. However, it remains certain that the contribution of biofuels will be limited because of land availability constraints; unless advances in technology make possible higher biomass production, yields and conversion, with significantly lower costs.

On the point of view of greenhouse gases concerns, the overall interest of biofuels i.e. CO2eq savings relies on the overall performances of agro-ecosystems, which in most cases and for all agricultural production require improvement.

The climatic conditions prevailing in Guinea are particularly appropriate for the growth of the Jatropha crop and the obtaining of a sizeable quantity of oil for constructing of a sustainable biodiesel industry. However, the lack of scientific knowledge on key parameters, such as seeds genetic potential, best engineering practices, and most favorable soil properties, prevents the development of operative farmer extension services.

Nowadays the only type of *Jatropha* recommendable plantation for smallholders is the fence. Because this survey shows that a *Jatropha* fence represents a durable investment for smallholder farmers, furthermore it is also a widespread, existing use of *Jatropha* that farmers are aware of and may adopt quite easily without food versus fuel production conflict risk. The fence also has the additional benefit of protecting valuable plantation crops from trespassing wildlife and people.

Experimental cultivation and plots are required to provide reliable and more consistent data on the influence of soil properties and water regime on the oil potential of Jatropha seed.

Seed samples collected from life fences show good characteristics of 1000 seed-weight, oil content. The major fatty acids in Jatropha oil were the oleic acid, linoleic acid, palmitic acid and the stearic acid. Biofuel from Jatropha oil, with a high content of unsaturated fatty acid has a relatively short induction periods about 6 hours. Transesterified Jatropha oil is unstable and easily oxidized in presence of air. Oxydation of transesterified Jatropha oil results with formation of hydroperoxides as primary products which are very unstable. They are cleaved and form secondary products such as shorter chain fatty acid, aldehydes, ketone, hydrocarbons and alcohol.

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