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Characteristics and Composition of *Jatropha curcas* Oils, Variety Congo-Brazzaville

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Abstract: The oil from *Jatropha curcas* seeds variety "Congo-Brazzaville" was extracted using two oils extraction methods with petroleum ether (Soxlhet) and extraction with a mixture of chloroform:methanol (1:1) (Blye and Dyer). The oils were compared of *Jatropha curcas* other countries. The oil concentration ranged from 50% (Soxlhet) to 47% (Blye & Dyer). The minerals, viscosity, acidity, saponification value, iodine value, fatty acid methyl esters, unsaponifiable matter content, peroxide value, activation energy and differential scanning calorimetry were determined. *Jatropha curcas* seeds have ash content of 4.2% (with the presence of following minerals: Ca, Mg, K and Na). The oil was found to contain high levels of unsaturated fatty acids, especially oleic (up to 40.10%) and linoleic (up to 37.60%). *Jatropha curcas* oil can be classified in the oleic-linoleic acid group. The dominant saturated acids were palmitic (up to 15.63%) and stearic (up to 5.78%). *Jatropha curcas* seeds were also founded to contain high levels of crude protein (25%). The content of insaponifiables is 0.89 %. Taking into account these results, *Jatropha curcas* can be cultivated for the production of oil of technical interest (biocarburant, soap, painting, lubricants, insecticides, etc).

Key words: Activation energy, DSC, fatty acid, *Jatropha curcas* seeds, nutritive values and viscosity

INTRODUCTION

Jatropha curcas (euphorbiacée called pinion of India) is a species originating in the Indies and currently widespread in the villages of tropical Africa (Adjanohoun *et al*., 1989). In Congo, this plant is found in almost all the areas. The population uses it for the clothes industry of the fences and in the pharmacopeia, in reason of its many therapeutic virtues (Kerharo, 1974). *Jatropha curcas*, is a drought resistant tropical tree and the oil from its seeds has been found useful for medicinal and veterinary purposes, as insecticide, for soap production and as a fuel substitute (Gubitz *et al*., 1999).

There is a large variability in different accessions of *Jatropha curcas* from diverse agro climatic regions (Kaushik *et al*., 2007). Augustus *et al.* (2002) have reported that *Jatropha curcas* seeds contain around 20-40% oil. Its oil fraction consists of both saturated (14.1% palmitic acid and 6.7% stearic acid) and unsaturated fatty acids (47% oleic acid and 31.6 of linoleic acid). Recently, there is a report (Martinez-Herrera *et al*., 2006) reported that the major fatty acids found in the oil samples were oleic (41.5-48.8%), linoleic (34.6-44.4%), palmitic (10.5-13.0%), and stearic (2.3-2.8%) acids.

Because of the strong competition between human consumption and the soap factory for the use of vegetable oils, it is advantageous that Africa develops other sources of vegetable oils of production. *The curcas of Jatropha* is instigator, because the seed contains oil 58% roughly (Kerharo, 1974).

MATERIALS AND METHODS

This study was led to the laboratory of engineering and biomolecule of the ENSAIA-INPL, Vandoeuvre–lès-Nancy (France) for the period of Jan. 5, 2009 to Feb. 27, 2009.

Materials: Mature *curcas of Jatropha* pods were collected from neighborhood gardens around University Campus "Marien Ngouabi" of Brazzaville. The seeds were removed from the pods, sorted and sun dried. Only seeds that were not damaged were chosen and stored under cool dry storage conditions until needed.

Methods: Proximate analysis of *Jatropha curcas* seed Moisture, crude protein (micro-Kjeldahl), crude fibre and oil (Soxhlet) contents were determined using the methods

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described by Pearson (1976), whereas the ash content was determined using the method of Pomeranz *et al.* (1994), and total carbohydrate was determined by difference. All determinations were done in triplicate.

Oil extraction: Dried *Jatropha curcas* seeds were ground in a Moulinex Model SeB PREP'LINE 850 (Moulin cafe). For solvent extraction (soxlhet method), 50 g of ground seeds were placed into a cellulose paper cone and extracted using light petroleum ether (b.p 40–60 °C) in a 5–l Soxhlet extractor for 8 h (Pena *et al*., 1992). The oil was then recovered by evaporating off the solvent using rotary evaporator Model N-1 (Eyela, Tokyo Rikakikal Co., Ltd., Japan) and residual solvent was removed by drying in an oven at 60 °C for 1 h and flushing with 99.9% nitrogen. For methanol/chloroform extraction (Blye and Dyer, 1959), 100g of the ground seeds were homogenised with a chloroform mixture methanol (1:1) and water. Two phases was obtained, aqueous layer (methanol-water) and organic layer (chloroform). Oil was recovered by evaporating off the solvent (chloroform) using rotary evaporator Model N–1 (Eyela, Tokyo Rikakikal Co., Ltd., Japan) and residual solvent was removed by drying in an oven at 60 ºC for 1 h and flushing with 99.9% nitrogen All experiments were done in triplicates and the mean and standard deviations were calculated.

Physical and chemical analysis of crude oil:

Thermal behaviour: The thermal property of the oil samples was investigated by differential scanning calorimetry using a Perkin–Elmer Diamond DSC (Norwalk,USA). The instrument was calibrated using indium and zinc. The purge gas used was 99.99% nitrogen with a flow rate of 100 ml.min^{-1} and a pressure of 20 psi. Sample weights ranged from 5–7 mg and were subjected to the following temperature program: Frozen oil sample was heated at 50 °C in an oven until completely melted. Oil sample was placed in an aluminium volatile pan and was cooled to –50 °C and held for 2 min, it was then heated from – 50 to 50 ºC at the rate of 5 °C/min (normal rate) (Che Man *et al*., 1995) and 2.5 °C/min (past rate), and held –50 °C isothermally for 2 min and cooled from –50 to 50 °C at the rate of 5 °C per minute. The heating and cooling thermograms for the normal and the fast (hyper DSC) scan rates were recorded and the onset, peak, and offset temperatures were tabulated. These values provide information on the temperature at which the melting process starts, the temperature at which most of the TAG have melted, and the complete melting temperature of the oil, respectively.

Viscosity measurements: A rheometer as described by Nzikou *et al*., (2007) was used to measure the different oil viscosities. By this procedure, a concentric cylinder system is submerged in the oil and the force necessary to overcome the resistance of the viscosity to the rotation is measured. The viscosity value, in mPas, is automatically calculated on the basis of the speed and the geometry of the probe. Temperature (20 °C) was controlled with a water bath connected to the rheometer. The experiment was carried out by putting 3 ml of sample in a concentric cylinder system using 100 s^{-1} as shear rate.

Chemical analysis: Determinations for peroxide, iodine, saponification values, unsaponifiable matter and free fatty acid contents were carried out using Pena *et al*., (1992) standard analytical methods. The fatty acid composition was determined by conversion of oil to fatty acid methyl esters prepared by adding 950 µl of n-hexane 50 mg of oil followed by 50 µl of sodium methoxide using the method of Cocks *et al*., (1966). The mixtures were vortex for 5 s and allowed to settle for 5 min. The top layer (1 µl) was injected into a gas chromatograph (Model GC- 14A, Shimadzu Corporation, Kyoto, Japan) equipped with a flame-ionisation detector and a polar capillary column (BPX70 0.25), 0.32 mm internal diameter, 60 m length and 0.25 µm film thickness (SGE Incorporated, USA) to obtain individual peaks of fatty acid methyl esters. The detector temperature was 240 °C and column temperature was 110 °C held for one minute and increased at the rate of 8 °C.min^{-1} to 220 °C and held for one minute. The run time was 32 min. The fatty acid methyl esters peaks were identified by comparing their retention time with those of standards. Percent relative fatty acid was calculated based on the peak area of a fatty acid species to the total peak area of all the fatty acids in the oil sample. The minerals were determined by atomicabsorption spectrophotometry. One gram samples, in triplicate, were dry ashed in a muffle furnace at 550°C for 8 h until a white residue of constant weight was obtained. The minerals were extracted from ash by adding 20.0 ml of 2.5% HCl, heated in a steam bath to reduce the volume to about 7.0 ml, and this was transferred quantitatively to a 50 ml volumetric flask. It was diluted to volume (50 ml) with deionised water, stored in clean polyethylene bottles and mineral contents determined using an atomic absorption spectrophotometer (Perkin-Elmer, Model 2380, USA). These bottles and flasks were rinsed in dilute hydrochloric acid (0.10 M HCl) to arrest microbial action which may affect the concentrations of the anions and cations in the samples. The instrument was calibrated with standard solutions.

Statistical analysis: Values represented are the means and standard deviations for three replicates. Statistical analysis was carried out by Excel Version 8.0 software. Significance was defined at $P < 0.05$.

RESULTS AND DISCUSSION

Proximate analysis of *Jatropha curcas* seed oil: Results obtained showed that the seeds contained 5.12% moisture, 48.5% crude oil, 25% crude proteins, 7.78% carbohydrate (by difference), 9.4% crude fiber and 4.2% ash (Table 1). The high percentage of oil makes this seed a distinct potential for the oil industry. According to Münch and Kiefer (1986), the mature seed yields 36–64% oil.

Table 1: Proximate analysis of *Jatropha curcas* oil seed

Characteristic	Obtained values[a] (M ± SD)	Reported values[b]
		1
Moisture content (%)	5.12 ± 0,24	5.54
Crude protein[c](%)	25 ± 0.20	24.60
Ether extract (%)	48.50 ± 0.18	47.25
Crude fibre (%)	9.4 ± 0.12	10.12
Ash content (%)	4,2 ± 0,29	4.5
Total carbohydrate[d] (%)	7.78	7.99

[a] M ± S.D. mean ± standard deviation.
[b] (1) Akintayo (1997).
[c] Crude protein = N (%) x 6.25
[d] Carbohydrate obtained by difference

Table 2: Mineral elemental Composition of *Jatropha curcas* seeds

Mineral elements	Composition (mg/100g) of Seed
Calcium, Ca	455.38 ± 3.14
Magnesium, Mg	483.30 ± 0.02
Potassium, K	518. 35 ± 0.44
Sodium, Na	30.29 ± 0.21

Values are mean ± S.D of triplicate determinations

Table 3: Physical and chemical properties of *Jatropha curcas* seed oil extracted using solvent process

Properties	Obtained values		Reported values[a]
	Blye & Dyer	Soxlhet	Solvent extract
Oil[b] (%)	47.0 ± 2.35^{B}	50.0 ± 2.35^{A}	47.25
PV	0.13 ± 0.28^{A}	0.21 ± 0.44^{A}	ND
FFA (as % oleic acid)	3.08 ± 0.20^{A}	2.24 ± 0.17^{B}	3.5
IV (wijs)	98.89 ± 0.23^{A}	102.43 ± 1.12^{A}	105.2
Saponification value	166 ± 1.24^{A}	167 ± 0.81^{A}	198.85
Unsaponifiable matter Content (%)	0.87 ± 0.02^{A}	0.90 ± 0.07^{B}	0.8
Viscosity (mPa.s) at 20°C	36.28 ± 0.28^{B}	48.35 ± 0.27^{B}	ND
E_a (KJ. mol^{-1})	13.96	13.77	ND

ND: not determined
Means for the determined values in the same row followed by the same superscript letter are not significantly different ($p < 0.05$)
[a] Akintayo *et al.* (2004)
[b] Oil = weight of extracted oil x, 100/weight of seed
Abbreviations: PV: Peroxide Value, FFA: Free Fatty Acid, IV: Iodine Value.

Akintayo (1997) reported a 47.25% yield by weight of the seed. Variation in oil yield may be due to the differences in variety of plant, cultivation climate, ripening stage, the harvesting time of the seeds and the extraction method used.

Minerals: It is of interest to note that the most prevalent mineral element in *Jatropha curcas* seeds is Potassium which is a high as 518.35 ± 0.44 mg/100g dry mater (Table 2). Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins (Malik, 1982), Magnesium (483.30 ± 0.02 mg/100 g dry matter) plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agents of cell walls (Russel, 1973). Calcium (455. 38 ± 3.14 mg/100 g dry matter) is also the major component of bone and assists in teeth development (Brody, 1994).

Oil extraction: Characteristics of the oil were compared with *Jatropha curcas* varieties others country, described

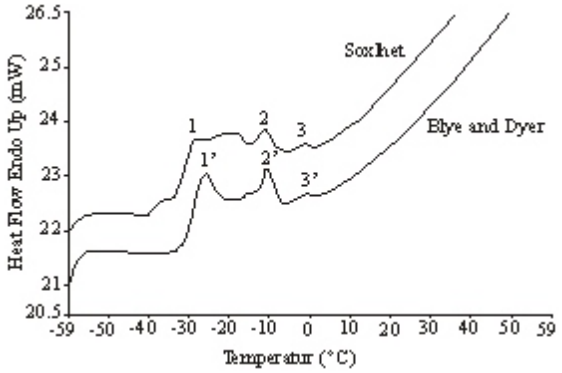

Fig. 1: Heating profiles of *Jotropha Curcas* oil extracted by two methods (Blye and Dyer and Soxlhet), at 2.5°C.min^{-1} scan rate

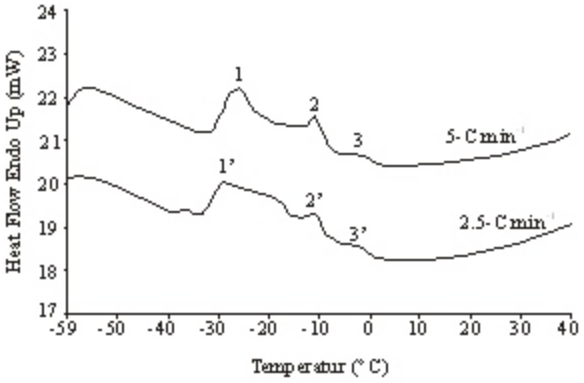

Fig. 2 : Heating profiles of *Jatropha Curcas* oil extracted by Blye & Dyer method, at 2.5° and 5° C.min^{-1} scan rate

by Akintayo (2004) and Kpoviessi *et al.*, (2004). The extracted oils were liquid at room temperature. The oil content of *Jatropha curcas* "Congo-Brazzaville" seeds and the level at which the differences are significant are shown in Table 3. The oil extraction with the Soxlhet method had the highest yield, due to the increased ability of the solvent to overcome forces that bind lipids within the sample matrix (Lumley *et al.*, 1991). The Blye and Dyer method, showed the low yield due to losses during the separation of the two phases, aqueous layer (methanol-water) and organic layer (chloroform). The results of the above authors agree with those of the present work.

Physical and chemical properties of oil:

Physical properties:

Differential Scanning Calorimetry (DSC): DSC is suitable to determine these physical properties. Results obtained from the heating with the DSC (Table 4) showed slight differences in both melting behaviour for the two oil samples when temperatures scanning (2.5 °C.min^{-1} and 5 ºC.min^{-1}) were used. The heating profiles using the scan rate (2.5 °C.min^{-1} and 5 °C.min^{-1}) for the two extractions methods showed that there is three peaks (1, 1'), (2,2') and (3, 3') respectively (Fig. 1, 2). The shoulder peaks 1 and 1' represented the melting

temperature of unstable crystals of the low melting TAG that pre-maturely melted. The more stable low melting unsaturated TAG crystals melted at a higher temperature shown as peaks 2 and 2'. The higher melting, more saturated TAG peaks (3 and 3') appeared at higher temperatures.

Table 4, shows the presence of three peaks for each oil sample obtained by the two extraction methods, at various speeds (2.5 and 5 °C.min^{-1}). At 2.5ºC min^{-1}, the first peaks for the two methods appear to −26.11 and −31.54 °C with fusion enthalpy (H_f) of +13.76 and −5.36 J.g^{-1}, while to 5 °C.min^{-1}, the first peaks appear to −26.11 and −31.54 °C with fusion enthalpy (H_f) of +12.64 and −5.91 J.g^{-1}. These first peaks are due to PUFA (Poly Unsaturated Fatty Acid) presence. The second peaks for the two methods, appear to −10.49 and −7.03 °C with fusion enthalpy (H_f) of +2.73 and 49.56 J.g^{-1} (2.5 °C.min^{-1}), at 7.70 and −10.11°C with fusion enthalpy (H_f) of −0.87 and +0.42 J.g^{-1} (5 °C.min^{-1}). These second peaks correspond to the MUFA (Mono Unsaturated Fatty Acid) fraction. The last peaks which appear to −0.70 and −1.82 °C with fusion enthalpy (H_f) of +0.22 and +0.15 J.g^{-1} (2.5 °C.min^{-1}), at −0.83 and −1.54 °C with fusion enthalpy (H_f) of +0.35 and +0.50 J.g^{-1} (5 °C.min^{-1}), concern the SAF (Saturated Fatty Acid) presence.

Viscosity: Viscosity is a measure of resistance of a fluid to deform under shear stress. It is commonly perceived as thickness, or resistance to pouring. Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction. In optics to know the rheological proprieties of these oils, we studied the influence of temperature on viscosity. Activation energies of the various classes of fatty acids contained in these oils were given Table 3. When the temperature increases, viscosity decreases exponentially (Fig. 3) some is the extraction method (Arsland *et al*., 2005; Nzikou *et al*., 2007). Viscosity varies between 71.20 and 31.63 mPa.s when temperature decreases of 50 to 5 ºC by Blye and Dyer method. By Soxlhet method, the viscosity of oil decreases of 55.50 to 24.90 mPa.s (Table 5). The viscosity of the oil obtained by Blye and Dyer method was highest, possibly because of the water that was absorbed by the gums (phospholipids) during extraction. This calculator calculates the effect of temperature on reaction rates using the Arrhenius equation.

Where η is the viscosity, A is constant, Ea is the activation energy (in KJ mol^{-1}), R is the universal gas constant and T is the temperature (in degrees Kelvin). R has the value of 8.314 x 10^{-3} KJ mol^{-1} K^{-1}. We should use this calculator to investigate the influence of temperature on viscosity. Linear regression analysis was applied to the logarithmic form of Arrhenius equation in order to determine the parameters of the relation (Fig. 4, Table 6). lnη against 1/T, −Ea/RT is the slope from which E_a was evaluated. Activation energies of oils are given in Table 3. The highest value of activation energy is obtained by Blye and Dyer. method (13.96 KJ mol^{-1}) and 13.77 KJ mol^{-1} by Soxlhet method.

Table 4: Melting behaviour of *Jatropha curcas* seed oil using different scan rates. Experimental conditions: temperature program set at −50°C for 10 min, rising to 50°C at rate of 2.5°C.min^{-1} and of 5°C.min^{-1}

Thermogram	2.5°C/min		5°C/min	
	Blye and Dyer	Soxlhet	Blye and Dyer	Soxlhet
Peak 1 [°C]	−25.44	−31.10	−26.11	−31.54
ΔH_f [J/g]	+13.76	−5.36	+12.64	−5.91
Peak 2 [°C]	−10.49	−7.03	−7.70	−10.11
ΔH_f [J/g]	+2.73	+49.56	−0.87	+0.42
Peak 3 [°C]	−0.70	−1.82	−0.83	−1.54
ΔH_f [J/g]	+0.22	+0.15	+0.35	+0.50

Table 5: Oil viscosity at various temperature in degree celsuis (Fig. 4)

T (°C)	η (mPa.s)	
	Blye and Dyer	Soxlhet
5	71.2	55.5
10	61.8	47.9
15	54.8	41
20	48.35	36.28
25	43.8	32.70
30	39.96	30
35	36.74	27.54
40	33.89	25.7
45	32.54	24.9
50	31.63	24.9

Table 6: Energie plot derived from the Arrhenius equation (Fig. 5)

1/T (K^{-1})	Lnη (mPa.s)	
	Blye and Dyer	Soxlhet
0.00359712	4.26549282	4.01638302
0.00353357	4.12390336	3.8691155
0.00347222	4.00369019	3.71357207
0.00341297	3.87846622	3.59126663
0.0033557	3.77963382	3.48737508
0.00330033	3.68787895	3.40119738
0.00324675	3.60386608	3.31563949
0.00319489	3.52311999	3.24649099
0.00314465	3.4824701	3.2148678
0.00309598	3.45410604	3.18635263

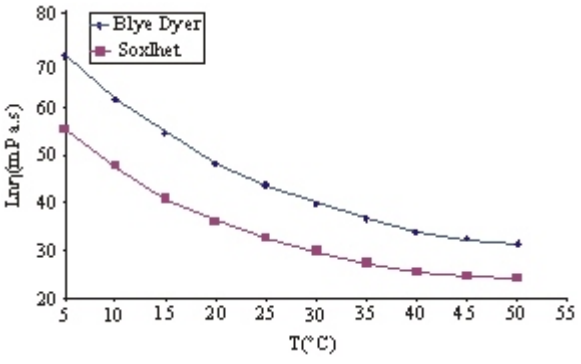

Fig. 3: Effect of temperature on *Jatropha curcas* seed oil viscosity

Chemical properties: The chemical properties of oil are amongst the most important properties that determines the present condition of the oil. Free fatty acid and peroxide values are valuable measures of oil quality. The iodine value is the measure of the degree of unsaturation of the

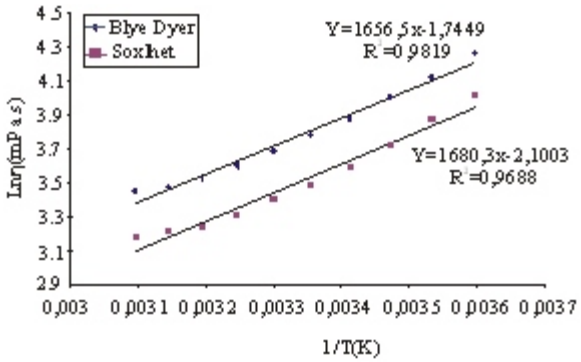

Fig. 4: Relationship between viscosity and temperature for *Jatropha Curcas* seed oil extracted by Blye and Dyer and Soxlhet. Solid line Arrhenius model

oil. The free fatty acid and the unsaponifiable matter content of the Soxlhet method were significantly higher ($P < 0.05$) than those of the Blye and Dyer method (Table 3). There was no significant difference in the iodine and saponification values, in the two extraction methods ($P > 0.05$). The slightly higher value of unsaponifiable matter in the Soxlhet method may be due to the ability of the solvent to extract other lipid associated substances like, sterols, fat soluble vitamins, hydrocarbons and pigments (Bastic *et al*., 1978; Salunke *et al*., 1992).

Fatty acid composition: The major saturated fatty acids in *Jatropha curcas* seed oil were palmitic and stearic acids; the main unsaturated fatty acid were oleic acid (40.10%) and linoleic acid (37.51%) with small amounts of palmitoleic acid (Table 7). There was no significant difference ($P > 0.05$) in the amounts of the major fatty acids in the two oil samples. The two oil samples of *Jatropha curcas* contained saturated and unsaturated acids (21.41% and 78.60%) respectively.

Jatropha curcas oil can be classified in the oleic-linoleic acid group. Linoleic acid which is one of the most important polyunsaturated fatty acids in human food because of its prevention of distinct heart vascular diseases (Boelhouwer, 1983). *Jatropha curcas* oil is predominantly made up of oleic and linoleic acids (40% and 37.51%) respectively. One notes a small quantity of stearic acid C18:0 (5.78 %). It is observed 0 % of linolenic acid C18:3 and a smaller percentage of acid palmitoleic C16:1 (1 %) (Table 7). The results obtained are in agreement with those of the literature Akintayo *et al*. (2004) Kpoviessi *et al*. (2004) and Augustus *et al*., (2002).

Unsaturated total fatty acids are prevalent (78.60 %) (Table 7). This prevalence of the unsaturated fatty acids and the high values of the iodine index indicate that the oil of *Jatropha curcas* of Congo-Brazzaville is of *the unsaturated type.* The comparison of the composition in fatty acids of *Jatropha curcas* seed oil with that of vegetable oils (Table 8) indicates that this plant is rich in acids oleic (C18:1), linoleic (C18:2) and palmitic (C16:0); nevertheless, the presence of a toxalbumin, the curcine, makes this oil unsuitable to consumption (Kpoviessi, 2004). *Jatropha curcas* seed oil of Congo shows a linoleic rate of acid high C18:2 and a profile in fatty acid near to that of Mexico i.e. rich in oleic acid C18:1, linoleic acid C18:2 and palmitic acid C16:0 (Table 9). Other countries (Benin, Togo, Cape-Vert, Sao Tomé et Principe, Paraguay, India and Pakistan) present a profile in fatty acids very near. This comparison makes it possible to conclude that one notes little variation in the chemical composition of seeds different geographical origins.

CONCLUSION

Jatropha curcas oil is of unsaturated type and contains mainly the fatty acids oleic C18:1(40 %), linoleic

Table 7: Relative percent composition of fatty acid in *Jatropha curcas* seed oil

Fatty acid	Determined values		Reported values[a]		
	Blye & Dyer	Soxlhet	1	2	3
C16:0	16.07 ± 1.53 ^{A}	15.19 ± 1.43 ^{A}	19.5	13 – 16	14.1
C16:1	0.9 ± 0.12 ^{A}	1.12 ± 0.15 ^{A}	–	0.8	–
C18:0	6.03 ± 0.18 ^{A}	5.52 ± 0.18 ^{B}	6.8	2 – 9	6.7
C18: 1	41.39 ± 0.38 ^{B}	38.76 ± 0.21 ^{A}	41.3	41– 49	47
C18:2	35.61 ± 0.12 ^{A}	39.41 ± 0.20 ^{A}	31.4	29 – 47	31.6
C18:3	–	–	–	–	–
C20:0	–	–	–	–	–
Saturated	22.10	20.71	26.7	ND	20.8
Unsaturated	77.90	79.29	72.7	ND	78.6

ND: not determined., Means for the determined values in the same row followed by the same superscript letter are not significantly different ($P < 0.05$).
[a](1) Akintayo *et al.* (2004). (2) Kpoviessi *et al.* (2004). (3) Augustus *et al.* (2002)

Table 8: Comparison of the profile in fatty vegetable oil acids

Huiles	C14:0	C14:1	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0
Palm	1.0	–	44.5	0.2	4.6	38.7	10.5	0.3	0.3
Safou	–	–	44.5	–	2.8	28	24.9	1.24	–
Maize	–	–	10.5	–	2.5	28	58.5	1.0	0.5
Groundn	–	–	10.0	–	2.0	46.0	31.0	–	–
ut Cotton	–	–	23.0	–	2.2	17.7	55.8	–	–
Hazel nut	0.9	–	7.0	0.1	2.0	74.5	16.5	–	–
Soybean	–	–	11.0	–	4.0	22.0	54.3	7.5	–
Jatropha	–	–	15.6	1.0	5.8	40.1	37.6	–	–

Table 9: Comparison of the profile in oil fatty acids of *Jatropha curcas* of various origins

Origin	Composition in fatty acids (%)					
	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3
Congo	15.6	1.0	5.8	40.1	37.6	–
Benin	14.6	0.8	7.4	47.5	28.7	1.0
Togo	15.0	–	6	44	35	–
Cap-Vert	17.1	–	6.6	41.3	30.5	–
Sao Tomé P	13.1	–	7.8	49.0	28.6	–
Mexique	15.2	–	9.1	37.6	38.0	–
Brésil	13.1	–	6.6	32.8	46.9	–
Paraguay	15.9	–	7.6	42.4	29.3	–
Inde	18.5	–	2.3	49.0	29.7	–
Pakistan	14.2	–	7.7	46.7	30.8	–

C18:2 (37%) and palmitoleic C16:1 (1%). the content of insaponifiables is 0.89 %. Taking into account these results, *Jatropha curcas* can be cultivated for the production of oil of technical interest (biocarburant, soap, painting, lubricants, insecticides, etc). Other oils, in particular the palm oil, cabbage tree, cotton, groundnut, etc, could then be completely available for the food.

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