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Performance analysis of a motorized screw-press designed for oil-extraction directly from whole seeds of *Jatropha Curcas* Linn. free air-dried

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Abstract

The importance of Jatropha oil is well established nowadays that global race to alternative agricultural sources to petroleum fuels is at agenda. In African countries and especially in Benin, the biggest constraint to lift is that relating to development of useful equipments for processing the potential agricultural sources of bio-fuels. This article presents achieved interesting results from a devoted research to designing, implementation and performance analysis of a motorized screw-press for a direct crushing-extraction of biodiesel-oil from whole seeds of *Jatropha Curcas*. Characterization of extracted-oil is realized and performances of designed screw-press are compared to those provided by similar technologies for showing its efficiency. The obtained experimental results allow concluding that, while the extraction yield, extraction rate and hourly output from traditional process do not exceeded respectively 53.0 %, 12.5 %, 1.73 L/h and those from Bielenberg press 45.59 %, 18.55 % et 1.94 L/h, the designed motorized screw-press has provided 59.74 %, 20.88 % and 2.90 L/h at 55℃. These results are doubly satisfactory: improvement of yield allowed by the devised press, interesting exit temperature of produced biodiesel, a very appropriate factor to oil quality preservation, reference being that from Soxhlet extraction method with petroleum ether as solvent at 60℃.

Keywords: motorized screw-press, whole seeds, free air-dried, Jatropha-oil, direct extraction.

Performances techniques d'une presse à vis motorisée d'huile des graines de *Jatropha Curcas* séchées à l'air libre

Résumé

L'importance de l'huile de Jatropha n'est plus à démontrer à l'heure actuelle où la course mondiale vers les sources agricoles de substitution aux carburants pétroliers est à l'ordre du jour. Dans les pays africains en général et au Bénin en particulier, la plus grosse contrainte à lever est celle relative aux équipements de transformation des produits agricoles sources potentielles d'agro-carburants. Le présent article expose les intéressants résultats atteints suite à l'investigation consacrée à la conception, la réalisation et l'analyse des performances d'une presse à vis sans fin destinée à la trituration-extraction directe de l'huile biodiesel contenue dans les graines entières de *Jatropha Curcas*. La caractérisation de l'huile extraite est effectuée avec succès et les performances de la presse conçue comparées à celles fournies par les technologies existantes montrant les qualités de la nouvelle presse à vis sans fin supérieures à celles de ces dernières. Les résultats expérimentaux obtenus permettent de conclure que, si le rendement d'extraction, le taux d'extraction et de production horaire du procédé traditionnel ne semblent pas dépasser respectivement 53,0%, 12,5%, 1,73 L/h ou ceux de la presse Bielenberg 45,59%, 18,55% et 1,94 L/h, la presse à vis motorisée conçue a fourni 59,74%, 20,88% et 2,90 L/h d'huile à 55℃. Ces résultats sont doublement satisfaisants: l'amélioration du rendement (permis par la presse conçue), intéressante température de sortie du biodiesel produit, un facteur très favorable à la conservation de la

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qualité de l'huile, en référence à la méthode d'extraction au Soxhlet avec l'éther de pétrole comme solvant à 60℃.

Mots Clés: presse à vis motorisée, graines entières, séchées à l'air libre, huile de Jatropha, performance.

INTRODUCTION

The regular spikes of crude petroleum prices and derivatives on one hand, the announced exhaustion of the proven world oil reserves and its recognized adverse impacts, such as climate change, have progressively forced political leaders, mainly African, to reconsider the development of new energy sources (Knothe *et al.*, 2005; Pramanik, 2003; Speight, 2010). Indeed, according to the USA gency for Governmental Information (IEA), consumption of the petroleum products will always be increasing: 88.64 million barrels/day in 2012 to 89.37 million barrels/day in 2013. Fear of exhaustion has obliged to invest in renewable energy resources such as bio-fuels and more specifically on the vegetable fuels (Fan et al, 2008; Speight, 2010). But, before a new energy source receives unanimous approval for being developed, it's imperative that it meets, in the current context, expressed criteria which are, not to be only ecologically clean, but also especially available and economically competitive in comparison with conventional petroleum products (Knothe *et al.*, 2005). In this regard, informed researchers have even postulated for the refinery of future and therefore warned refiners to take steps in view to adapt to it (Speight, 2010; Tchiégang *et al.*, 2005). The vegetable oils extraction is made, either by simple crushing - pressing at low temperature and physical separation, either by chemical means, or else by a combining these two techniques (Kartika, 2005; Knothe *et al.*, 2005; Manas, 2009; Morand-Fehr and Tran, 2001; Speight, 2010; Tchiégang *et al.*, 2005; Yé *et al.*, 2007). The use of an organic solvent made it possible achieving an extraction ratio of99%but at a higher cost. The raw and pure vegetable oils (RVO or PVO) could be directly used in suitable diesel engines or also in modified state before feeding motors due to their relatively high viscosity (Knothe *et al*, 2005; Mahajan *et al.*, 2006; Pramanik, 2003; Speight, 2010; Tchiégang *et al.*, 2005). Triglycerides, comprising vegetable oils, might be converted in to mono-methyl esters (Vegetable Oil Methyl Esters: VOME) and glycerol from trans-esterification reactions with methanol molecules (ethyl esters with ethanol). These obtained smaller bio-molecules could therefore be used as fuels of diesel engines (ASTM, 2007; Fan *et al.*, 2008; Oluwole *et al.*, 2004; Sanya *et al.*, 2009). The biodiesel, also known as Diester in France, did not contain sulfur and was often non-toxic, but had the property to be highly biodegradable. In Benin, the pure vegetable oil production (PVO) still currently proceeded by the simple extraction methods of pressing and settling, without any esterification, like that for edible oils. Traditionally, rural peoples produced vegetable oils by boiling in excess water, the raw material originally looted and crushed. They sometimes resorted to manual presses for small productions. Currently, various research programs concerned with pure vegetable oils in general and that of Jatropha in particular (Fan *et al.*, 2008; Knothe *et al.*, 2005; Pramanik, 2003; Tchiégang *et al.*, 2005; Yé *et al.*, 2007). The oil-extraction process from Jatropha seeds was as painful as it is now indispensable to seek rather to develop an appropriate technique to remove the linked constraints. The current experimental work has well integrated in its vision this goal by choosing to design a motorized press having improved technical performance. In this thinks' order, study of physical mechanical properties of seeds to be treated was absolutely essential for definition, design and implementation of the adequate press. Afterwards, a technical performance analysis was indispensable for the improvement and optimization of the devised motorized press.

MATERIALS AND METHODS

Vegetable Material

The treated vegetable material in current investigation consisted on the presented seeds (b) from the fruits (a) of *Jatropha Curcas* L. plant (Figure 1). This plant belonged to the known 177 Jatropha species originated from the Central and Southern America. It also grew all over the different regions of Benin territory. The shown seeds of figure 1 were those collected here and there at Lokossa city. Initially moist or fresh at picking, the seeds have not been submitted to other pre-treatment than just drying in the open-air at the laboratory temperature of 28 ± 2℃ for six d ays prior to their use. As indicated in introduction, physical-mechanical characterization of these same seeds, in one hand and their cotyledons on the other,

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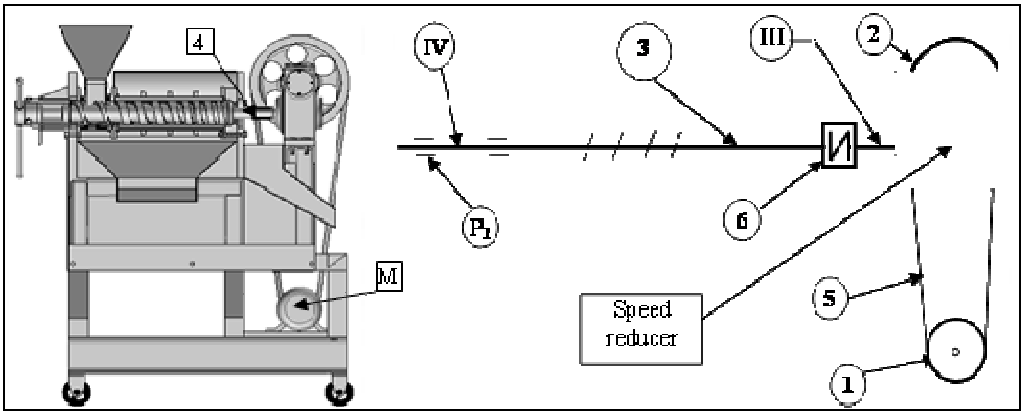
had been previously realized (Ahouansou *et al.*, 2010). The pursued main goal of current investigation is devoted to the design, manufacture and the performance analysis of resulting equipment, in view of a direct extraction of oil from the *Jatropha Curcas* seeds in their whole state. Usually, in the artisanal oil extraction process, Jatropha seeds are shelled before being crushed and ground, the resulting pulp is subjected to cooking with excess water, to reach the desired oil. The set objective, for the end of this study, is the development and testing of a motorized machine that grinds, kneads and extracts oil directly from dry seeds of *Jatropha Curcas*, quite to see how to clarify the obtained oil at the end of extraction.

Figure1. **Photography showing: (a)-Jatropha Curcas L. fruits, (b)- the used whole seeds (dried at open-air at room temperature 28±2°C in laboratory).**

Designed press description and its running mode

Technical equipment used in these experiments of direct crushing-extraction of contained oil in Jatropha seeds is the new designed and built screw-press shown on Figure 2. It is composed of six main parts: a framework, a body, a pressing system, a pressure control system, an electrical motor and a speed reducer.



Legend: M: motor; 1: motive pulley fixed to motor shaft lending; 2: receptive pulley; II: screw shaft in 6; 3: Archimedes screw; 4: hollow wheel; 5: motive belt; 6: coupling system; III: hollow gear shaft; IV: Archimedes screw shaft.

Figure 2. Assembly view of realized screw press at left and corresponding kinematic chain at right

The chassis is metallic frame on which operational part of the press fitted. It consists of a welding assembly of angle iron types, IPN and metallic plates. The press body rests on the chassis and is composed of a hopper, an oil collector channel, a cake collector channel or conveyor and the chassis covers. The defined and built mechanism, in the actual assembly press system, consists of a conveyor of Archimedes screw type, a pressure room and a pressure cone-shaped device. The kinematic chain of this developed press is exposed on the right of Figure 2. It helps disclosing the adopted technological principle in assembling the machine components as cited in legend of Figure 2. When motor M runs, its coupling-shaft rotates and drives the motive pulley (1) fixed at shaft end (I). This movement is transmitted to screw shaft (II) through the motive belt (5) and pulley (2). The shaft (II), fastened to pulley (2) and Archimedes

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screw (3) supported by the bearings P_1, transmits in turn the movement to shaft (III) of the hollow wheel (4). The latter, in turn, drives the Archimedes screw shaft of press by means of the coupling system (6). This defined, conceived and realized machine, is exclusively the fruit of acquired experiences on such locally manufactured machines types for processing of various crops (Ikegwuoha, 1998; Jossart, 2005; Okokon *et al.*, 2007; Omobuwajo *et al.*, 1999; Oloso, 1988; Oluwole *et al.*, 2007, 2004; Reichert *et al.*, 1979; Sanya *et al*., 2009; Yé *et al.*, 2007).

Performance parameters assessment

Three main parameters are used for performance characterization of this developed and experimented apparatus: extraction efficiency, oil-extraction rate and hourly capacity of press in terms of oil production. First, the extraction efficiency (η_{ex}) can be well describing by the use of "Equation (1)" which expresses, in percentage unity (%), the quantity (mass) of extracted oil (kg) per quantity (mass) of seeds contained oil (kg) multiplied by 100 (Jossart, 2005):

$$\eta_{ex} = 100 \cdot (M_{FS} - M_{FC})/M_{FS}(1 - M_{FC}) \quad (1),$$

Where: (M_{FS}) was percentage of fats in the seeds dry matter (dm) and (M_{FC}) the residual (remnant) oil content in seeds cake. This yield expression enabled determination of the oil amount that should be extracted from a known fallen seeds quantity in the pressure room of the used press (Manas, 2009).

Second, the extracted oil crude rate (E_{CR}) was obtained from application of the "Equation (2)"expressing as extracted oil weight divided by the amount of used seeds, multiplied by 100:

$$E_{CR} = 100 \cdot (M_S - M_C)/M_S \quad (2),$$

Where: M_S is the introduced seeds' mass and M_C mass of resulting cake after the oil extraction.

Third, the hourly capacity or throughput (C_h) could be expressed in relation with the quantity of extracted oil else to the amount of pressed seeds (Oluwole *et al.,* 2004). Indeed, in making a simple mass balance, the addition of the two (02) masses of wet oil and humid cake gave the total mass of pressed seeds by the designed equipment. If one effectively measured, by means of a timing, the taken duration for running the press in crushing a previously weighed seeds quantity, the hourly capacity of extracting oil (or crush-pressing seeds) might be expressed by the oil weight (respectively seed weight) per unit running time (t) (Sanya *et al.,* 2009; Yé *et al.,* 2007; Zavrajnov and Nikolow, 1990; Fliedel *et al.,* 1989).

$$C_{h(Oil)} = (M_S - M_C)/t \quad (3);$$

$$C_{h(Seeds)} = M_S/t \quad (4).$$

The operating temperature of the press, mainly at oil extracting point, was also an important parameter that must be absolutely controlled for oil quality insurance. Of course, higher operative temperature value could subsequently have adverse influences on the resultant oil quality (Pramanik, 2003; Tchiégang *et al.*, 2005**)**. For ensuring the validity of the ensued operative temperature, continuous measurements were effectively made at seven different points of the new press using ALLQA infrared thermometers types. The selected points for monitoring the temperature values included essentially those corresponding to the seeds entrance in feeding hopper, four successive points along the extraction cage, inside the extracted oil and in the seeds cake output of clamping cone.

Extracted-oil characterization

The screened characteristics for the extracted Jatropha seeds-oil were essentially the moisture content, acidity and calorific value, three important parameters for its best usage specifically in combustion engines and elsewhere. First of all, it's of commodity to evaluate the amount of extractable seeds-oil in available *Jatropha curcas* variety and the residual oil content of seeds cake (Ahouansou *et al.*, 2010; Knothe *et al.*,

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2005; Mahajan, 2006; Jossart, 2005; Pramanik, 2003; Speight, 2010). This in turn helps to quantify the performance to better qualifying the extraction technique used for this purpose.

Determination of oil content of the used *Jatropha Curcas* seeds

Assessment of fats content of seeds was performed, not only for knowing the amount of contained oil in the used Jatropha seeds, but also assessing to expected extraction performance of the designed equipment. The adopted method for cause was a part of that established, in preparing the various methyl esters of fatty acids by the International Union of Pure and Applied Chemistry (IUPAC) 12-1968/II Appendix D19 (AOAC, 1990; IUPAC, 1979; Morand-Fehr and Tran, 2001; Pramanik, 2003; Speight, 2010). The dosage of found fats, as in the whole seeds, as in ensued cake, had been achieved by the Soxhlet extraction method using petroleum ether as solvent. In procedural analyses, three (03) samples of approximately 10 g of finely ground seeds (resp. cake), have been removed, wrapped in filter paper and introduced in Soxhlet. The minimal time for extraction was eight (08) hours per sample and at fiber-jacket heating temperature of 60 ℃. Afterwards, the solve nt was removed by evaporation under vacuum condition using a Büchi Rota vapor-R evaporator type. Thee evaporation was pursued in a dryer-oven at105±2 ℃ for the residual moisture elimination. I n the drying time ending, this extracted oil, within the boiling glass flask, underwent periodic weighing sequences. The adopted periodicity was 1 hour, every weighing proceeding by cooling stay of 10-12 min in the ISO-9001 Nalgene desiccators until constant mass was reached. Observation of the mass stability was only confirmed after three consecutive measurements.

Determination of water content of extracted-oil

Three (03) samples of Jatropha seeds oil of initial mass M_i = 5 g were collected in pre-weighed empty cups and dried in an oven at 105 ± 2℃ for a period of 24 hours. Drying of samples was followed by periodic weigh in g at 1 hour intervals, until constant dry mass (M_e) recorded three consecutive measurements. During these tests, coming out of the oven and before each weighing, as previously underlined at the drying ending, the samples were cooled in the ISO9001 Nalgene desiccators for 10-12 min. The considered moisture for seeds samples in %, was arithmetical mean of obtained humidity from three testing samples calculated with the dry basis relationship: $W = 100 \times (M_i - M_e)/M_e$ (5)

Determination of Total Acidity Number (TAN) of extracted-oil

The determination of oil acidity was carried out according to ASTMD974 (or ISO-6619) standard method for Total Acidity Number (TAN) evaluation for petroleum products and lubricants. In the procedure, test sample of 10 ml of Jatropha oil was dissolved by continuous stirring in 100 ml solvent made of mixture of toluene (50%), isopropyl alcohol (49.5%) and distilled water (0.5%).This obtained mix solution was titrated using an alcoholic solution at 0.1 mol/L of potassium hydroxide (KOH) in the Norvanol (prepared by dissolving 5.61056 g of KOH in 1 L of Norvanol) with simultaneous monitoring of pH until reaching and exceeding the pH value equal to 11. The TAN values (in mg_{KOH}/g) were therefore calculated from the "Equation (6)" **(**Knothe *et al.*, 2005; Mahajan, 2006; Speight, 2010):

$$TAN = 56.1056 \cdot (V - V_B) \cdot [KOH]/M \quad (6),$$

where: V was the volume of KOH (ml) corresponding to value of pH =11 graphically determined from the established KOH volume curve as function of pH, V_B the KOH volume required for neutralizing the acidity of witness sample. This was chosen as constant and equal to V_B = 0.1 ml, [KOH] the potassium concentration (mol/L), M the mass (g) of taken oil sample volume of 10 ml using 1/100 accuracy laboratory weighing balance of Sarthorius type.

Evaluation of Calorific Value of extracted-oil

The Higher Calorific Value (HCV) of extracted oils was measured using a Mahler bomb calorimeter of PAAR type 1108 Model (Figure 3) calibrated with benzoic acid following the procedure of ASTMD240-76

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or 92 applicable to liquid fuels (ASTM, 2007; CEAEQ, 2010; Knothe *et al*, 2005; Speight, 2010**)**. The applied formulas for calculation of the oil's HCV-value are expressed as followed:

$$HCV = \left(\left[1{,}000 \cdot \left(T_F - T_I\right) \cdot K\right] - H_H \cdot M_H\right) / M_E \qquad (7)$$

in which the device constant $K = C_B \cdot M_B / \left[1{,}000 \cdot \left(T_F - T_I\right)\right]$ was determined using benzoic acid that having the mass M_B, combustion heat-value of $C_B = 26{,}453\ \text{kJ/kg}$ and the oil calorific value giving by $H_H = 1{,}000 \cdot K \cdot \left(T_F - T_I\right) / M_H$ where M_H represents the mass of oil, (T_1) the initial water temperature in tank measured before firing, T_F the final temperature maximum value i.e. after combustion and M_E the mass of the taken sample.

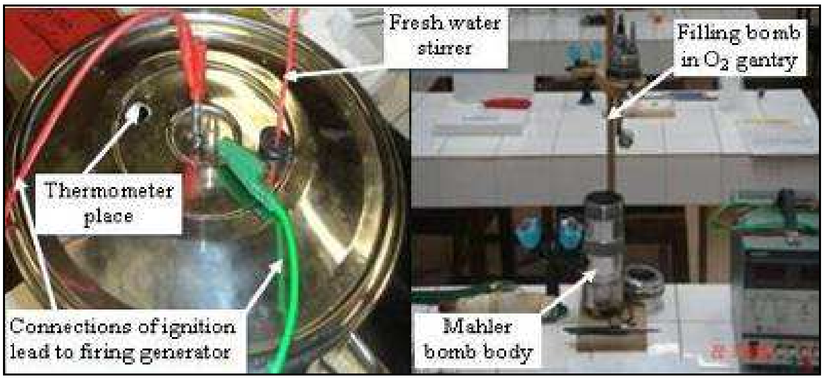

Figure 3. Photographs showing some components of the used Calorimeter Bomb of Mahler type in gantry ready for O_2 loading

By making the required corrections, classically used Lower Calorific Value (LCV) was therefore deduced with the aid of "Equation (8)":

$$LCV = \left[K \cdot \left(T_F - T_I\right) - \left(13.7 \cdot S \cdot M_E + 14.1 \cdot N + C_{ox} \cdot M_{mw}\right)\right] / M_E \qquad (8)$$

In "Equation (8)", correction constant 13.7 is that relating to sulfur content of fuel (S), 14.1 that of nitrogen (kcal/mol) and N the moles number of nitric acid due to nitrogen content as determined by titration of the washing water from calorimetric bomb vessel, and ($C_{ox}M_{mw}$) the oxidation heat of nickel firing wire with $\mathbf{C_{ox}}$ the oxidation heat and M_{mw} the mass of melted wire and M_E mass of fuel sample.

RESULTATS ET DISCUSSION

Results from press performance measurements

The recorded data on performance characteristics of the new built screw-press used in this experimental study were those gathered as example in the following Table1.Those exposed values originated from truly realized series of treatments, each based on fifteen (15) kilograms of Jatropha seeds. It appears from acquired data, that this conceived machine delivers, an extraction yield value of 59.64% at extraction rate of 20.88% and hourly capacity of 2.90 kg/h. In view of authenticating these obtained results, comparison is made with those encountered in the literature on the subject. It must however be underlined that, in considered literature data, no clear specifications have been given on the used technique for the involved fats dosage in the calculation of the announced performance yields. The provided performances by this motorized new Archimedes screw-press revealed characteristics values of which, those ensuing from the yield calculations, borrowed the known ethereal assay method that not allowing extraction of total fat matters. The industrial extractors of fatty matters, when using solvents of very higher grade in hot extraction, do not often reach to exceed a value of residual fats lower than 5.7% in the resulting cake from

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crushed seeds (Manas, 2009). It's known that removal of total fat matters from biological materials really proceeded from hot acidic hydrolysis and by the agreed laboratories.

Table 1. Performance characteristics from the screw-press designed for oil-extraction of Jatropha seeds free air-dried (15 kg per essay)

Measured parameters	Symbol (Unity)	Values	Standard deviation
Mass of seeds per essay	M (kg)	15.0	0.71
Seeds water content	W (% dry basis)	9.89	0.23
Mass of the extracted oil	$m_{H_{ext}}$ (kg)	1.04	0. 02
Obtained oil quantity	(mL)	746.0	0.43
Extraction time	(min)	103	1.02
Extraction yield	η_{ext} (%)	59.64	0.35
Extraction rate	T_{ext} (%)	20.88	0.21
Through put	C_h (kg/h)	2.90	0.04
Operating temperature	T (°C)	≈55.0	1.00

The Figure 4 depicted the evolution of recorded temperatures continuously at seven (07) different points of the press plant during pressing-extraction.

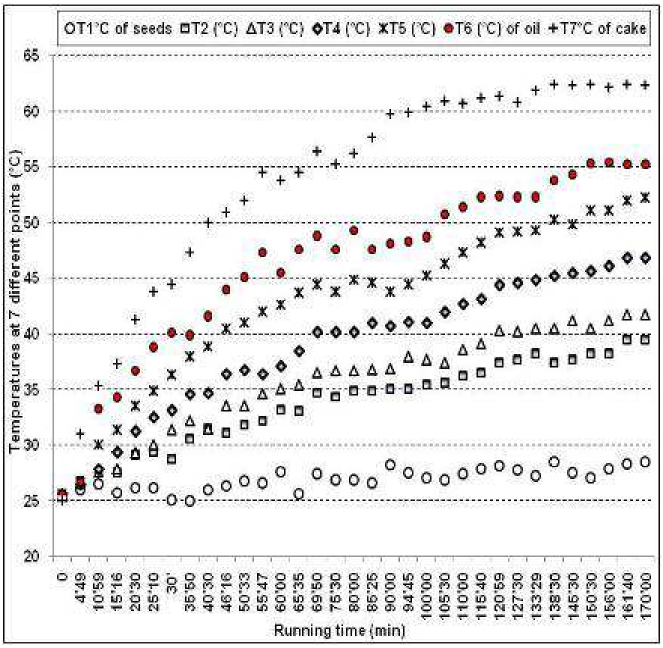

Figure 4- Recorded temperatures at seven (07) different points along the designed motorized screw press for oil extraction directly from whole seeds of Jatropha Curcas (oil at temperature T6)

The analysis of these shown data on figure 4 allowed knowing the located values of running temperatures, specifically between 25-28℃ at the seeds entrance in hopper and respectively 50-55℃ at output extracted oil on one hand, and 55-58℃ for seeds ca ke, on the other. These results make particularly known that the temperature of extracted-oil hardly attained 60℃: it truly remains around 55 ℃ (red p oints of legend in Figure 4). Let's remember that this temperature value of 60℃ is nothing else than that classically used value for heating the electric blankets tin Soxhlet extraction technique in a laboratory with petroleum ether as solvent. This result is quite interesting because this temperature value matches very well that for a better guarantee of a good conservation of the active components, mainly those exploitable in this extracted oil. As consequence, preservation of physicochemical and energetic characteristics represents, at least, the useful basic quality criteria for expecting a best behavior of extracted Jatropha oil during its combustion as it's the case for mineral fuel and the other known vegetable oils.

In Table 2, are gathered the values of the monitored extraction yield, extraction rate and hourly capacity, with the respective three applied and studied means for processing the Jatropha seeds in current investigation: the traditional process, the Bielenberg press and the new designed motorized screw-press.

Table 2. Compared performance characteristics values of three (03) extraction processes:1-traditional, 2-by Bielenberg press, 3- the proposed new motorized screw press

Performance characteristics of the tested methods		Three (03) compared seeds oil extraction processes:		
		1	2	3
		Traditional method	Bielenberg press	Newscrew press
Extraction yield	η_{ext} (%)	53.0	45.59	**59.64**
Extraction rate	T_{ext} (%)	12.50	18.55	**20.88**
Throughput	C_h (kg/h)	1.73	1.94	**2.90**

The compared values were given for guidance in this table, because, for a reliable conclusion, experiments should have been realized in situ on the Bielenberg press using the same varieties of Jatropha seeds. Indeed, it is not very commode to compare the recorded results of compression methods based on different seeds variants. Farming methods and often the maturity of seeds at harvest could influence the chemical constituents, in particular, the existing ratio between mono- and -poly unsaturated components. These were all of the factors that might explain the noticed differences in composition of the extracted oils from collected Jatropha L. seeds in various geographic areas (Mahajan, 2006). Assuming that the treated seeds and methods of performance parameters evaluation were identically the same, the results of this comparison led to the following three main conclusions. Firstly, the designed and built new press allowed achieving a value of extraction yield of 59.64% while provided respective yields values by the traditional method and Bielenberg press were lower with 53% and 45.59%. Secondly, the new press provided extraction rate value of 20.88%, higher than that obtained, as well from the traditional hot-water method (18.55%), as that of existent Bielenberg press (12.50%).Thirdly and finally, the proposed new press delivered an hourly capacity of 2.90 kg/h against 1.73 kg/h for the traditional extraction method and 1.94 kg/h for the Bielenberg press. According to those obtained interesting results from the motorized Archimedes screw press, in comparison with the considered other two techniques, it could easily be concluded that this new press furnished the best performance characteristics. However, it might be pointed out that, at this level of performance of the developed new press, the delivered capacity, while higher than Bielenberg one, remained relatively feeble enough to intend for a significant production of Jatropha oil. Complementary works are absolutely required for the designed and tested device yield improvement. The same trend can be pointed out and same comments applied to this reached value for oil extraction rate: 20.88%. It must be underlined that this value is relatively low compared to the one from a used laboratory press for extraction of butter from shea almonds with 34 ± 6% (Yé *et al.*, 2007). These authors have applied a method in which the exploited press was equipped with a heating system. The latter was devoted to weakening of the material structure of shea seeds at operative temperature of 70℃ prior to extraction of the contained butter. The weakened homogenates crushed almonds were then subjected to a extraction pressure value of 7 MPa. Some hydro-mechanical presses operating at higher pressure (20 MPa) and to embrittlement temperature of material up to 90℃, have allowed reaching highe r rates for shea butter extraction: 75 ± 3%. The developed screw-press is much closer to the press-extruders of AXIA type for which the respective published extraction yields values by manufacturer are of 41% for rapeseeds and 46 ± 3% for sunflowers at the oil temperature not exceeding little 45℃ and the remnant fat matters in the seeds cake not as low as 11-13% for their best performer presses (Kartika, 2005; Manas, 2009).

In prospects of an attractive exploitation, seeing semi-industrial, it is indispensable to be able providing, to this screw-press, a significant improvement of reached technical performance at its current state. This must inexorably pass through resizing of apparatus, through devoted engineering calculations to increase reformat, so that, the new pilot press to be realized, takes absolutely into account the most important criterion of moment: that of higher throughput.

Results of extracted-oils quality

Influence of the seeds nature

The oil quality depended intimately on the seeds quality. Therefore, it was important to remember that the used seeds in this series of investigations were collected here and there in Lokossa city and simply dried in the open air at laboratory temperature of 28±2℃ for six (06) days without any other special precautions. Visually, all of the stocked seeds appeared healthy because no external damage could be distinguished on them. The periodic weighings, carried out for four (04) taken samples of wet seeds, each of them of 250 g, in the stock of prepared and conditioned seeds for experiments, have permitted monitoring and recording of disclosed drying kinetics on figure 5. Those curves reflected the behavior of the studied seeds during samples drying and prior to their exploitation, either by traditional method, else one or the other two presses used in current experiments. It must be noticed that, in one day (24 hours), each sample has lost more than 90% of its water content in the drying conditions listed above. One could also remarked that, the developed behaviors in drying (kinetic curves) of those tested samples of Jatropha seeds, showed very slight or almost negligible differences, reflecting the relative high homogeneity of these used seeds.

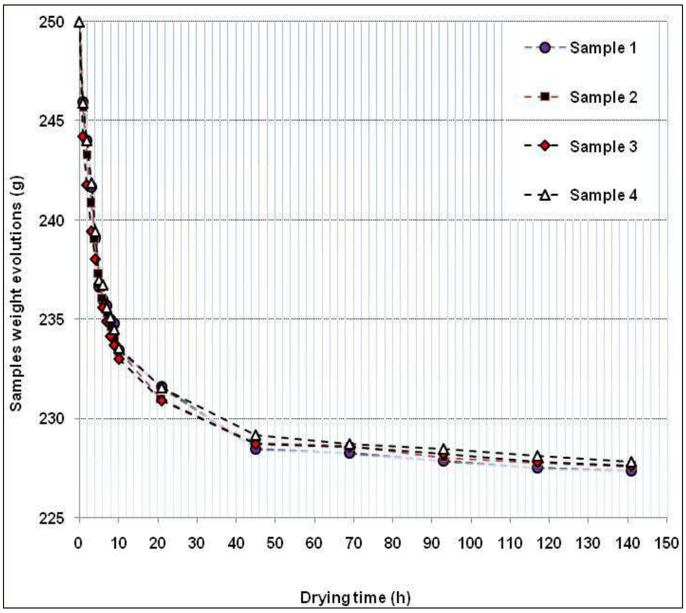

Figure 5. **Drying kinetics of four different samples of used Jatropha seeds (250g each, at room temperature of 28 ± 2°C in Laboratory)**

Physicochemical and energetic characteristics of extracted-oils

In Table 3, are displayed the obtained values at the end of the described different measurements and actually carried out, for some physicochemical and energetic parameters of extracted oils respectively by applying traditional method on one hand and running of new screw press, on the other. A review of the results exhibited in Table 3, it appeared that the developed screw press provided an oil of a higher density (0.856) and lower acidity (2.755 mg_{KOH}/g) than those of obtained oil from the traditional method wither spectively density of 0.847 and a TAN-value of 6.502 mg_{KOH}/g. The water content of extracted oil with this

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developed Archimedes screw press was very low (1.10%) compared to that produced by traditional method (5.33%). It could be underlined that the latter was five times higher than moisture content of processed oil from press. Justification might be found through the involved principles in applied extraction processes. Indeed, the tested seeds were introduced relatively dry: water content of 9.89 ± 0.23% dry basis (Table 1) in the machine and then pressed to extract oil directly. Hawks thereof thereby a certain amount of water content measured at 1.10%. In the traditional oil extraction process at contrary, excess water was added to ensued dough after the almonds grinding. In this practice, the added water for thinning the dough acts as a carrier fluid which ensures, at cooking step ending, the sought oil to float above it. The oil is then recovered by overflow on water surface. For this reason, the produced oil necessarily contains excess water contrary to the one resulting from the direct screw-pressing of seeds.

Table 3. Comparative physicochemical characteristics of the obtained *Jatropha Curcas* seed oils from two extraction methods: 1- by usage of designed press and 2- by traditional method

Measured characteristics	Extraction by the designed press: method 1	Traditional extraction: method 2
Water content on a dry basis(%b.s)	1.10 ± 0.17	5.33 ± 0.68
Fats content (%)	98.88 ± 0.83	94.67 ± 0.94
Acidity Number TAN (mg.KOH/g)	2.76 ± 0.91	6.50 ± 0.84
Dynamic viscosity at40 °C (mPa.s)	28.25 ± 0.32	28.92 ± 0.17
Kinematic viscosity at 40°C (mm^2/s)	33.23 ± 0.56	35.69 ± 0.83
Lower Calorific Value (kJ/kg)	43,978 ± 893	43,473 ± 789
Volumetric mass at 40°C (g/cm^3)	0.856 ± 0.011	0.847 ± 0.013
Oil density at 40 °C	0.856 ± 0.011	0.847 ± 0.013

It is probably superfluous to partially linking this noticed high acidity value for the extracted oil by traditional technique with the needed excess hot water at cooking. It could presumably provoke or initiate oxidative reactions, among some constituents of the extracted oil, in presence of supplied excess water and heat during the cooking step. Therefore, a deep chemical analysis is required for better elucidating the real causes of recorded high acidity rate in this extraction method.

CONCLUSION

The objective of achieving the new screw-press, for simultaneous crushing of seeds and extracting the contained oil in almonds of Jatropha Curcas L., was to lessen, seeing minimize, the linked constraints for oil access. The obtained results at the end of this experimental study are satisfactory and suggest meaningful progress towards a better future in terms of easy extraction and use of Jatropha oil for energy needs of villages and rural areas. The reached performances, in relation with yield and quality of extracted-oil, using this new press, are much interesting in comparison with those obtained from traditional technique and from press Bielenberg developed elsewhere for the same cause. The prospects that should be seriously considered, at the end of carried out experiments in this part of the study, relate to significant scale changes that must be introduced in the new motorized screw-press realized and tested, in order to highly improving technical performances reached.

NOMENCLATURE

- η_{ex}- *extraction efficiency*
- M_{FS}- *percentage of fats in the seeds dry matter*
- M_{FC}- *residual oil content in seeds cake*
- E_{CR}- *extracted oil crude rate*
- C_h- *hourly capacity of extracting*

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- *M_S- seeds weight*
- *M_C- seeds cake weight*
- *t- running time*
- *W- moisture content for seeds samples*
- *M_i- initial mass*
- *M_e- mass of empty cups*
- *V- volume of KOH corresponding to value of PH=11*
- *V_b- KOH volume required for neutralizing the acidity*
- *M- mass of taken oil sample volume of 10ml*
- *HCV- higher calorific volume*
- *K- device constant*
- *M_B- mass of benzoïc acid*
- *C_B- combustion heat volume*
- *H_H- oil calorific value*
- *M_H- oil mass*
- *T_i- water initial temperature*
- *T_F- maximum value of final temperature*
- *M_E- mass of the taken sample*
- *LCV- lower calorific value*
- *C_{or1}- correction constant relating to sulfur content of fuel*
- *C_{or2}- correction constant relating to nitric acid content of fuel*
- *C_{or3}- nickel fixing wire oxidation heat.*

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