

Research Article

Influence of Storage Time on the Quality of *Jatropha Curcas* Extracted Seed Oil

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Abstract: The aim of this investigation is to characterize *Jatropha curcas* seeds and to study the influence of seeds storage time on the extracted oil quality. The characterization process is done according to the French standards and the DIN standards are utilized as a basis for the extracted oil analysis as engine fuel. Two extraction methods are utilized, the solvent and the mechanical extractions. The maximum oil content, 40.42% is obtained from seeds having one year storage time and minimum water content of 4.48%. The oil acidity is also largely influenced by the same parameters. As a matter of fact, higher acidity percentage, 2.83% is obtained from seeds having respectively two years storage time and 7.15% water content whereas, the smaller percentage, 1.13%, is obtained with seeds of one year storage time and the same water content. The investigation has also shown that the oil content is function of the seeds origin. The maximum oil extraction rate (81.4%) is obtained with a specific mechanical energy consumption of 70 Wh/kg.

Keywords: Characterization, extraction, oil, quality, seeds of *Jatropha curcas*, storage time, standards

INTRODUCTION

Jatropha curcas is a species (of the euphorbiacée families also called pinion of India) originated from South America and is actually well widespread all over tropical and subtropical Africa and Asia countries (Henning, 2003a; Ogunwole *et al.*, 2007; Rijssenbeek *et al.*, 2007; Nzikou *et al.*, 2009). Its seeds contain between 20 to 40% of non comestible oil (Augustus *et al.*, 2002). Conventionally, *Jatropha curcas* oil can be extracted by two ways:

- The extraction by solvent has the advantage of producing oil of excellent quality with residues less than 5% (Augustus *et al.*, 2002; Sayyar *et al.*, 2009). Nevertheless, this operation is very slow, consumes quantities of solvent, some being toxic (Johnson and Lusas, 1983).
- The mechanical extraction utilizing a press is simple and well known but necessitates qualified operator to obtain oil of good quality (Ajibola *et al.*, 2000; Oyinlola and Adekoya, 2004). The efficiency of the extraction and the oil quality are both function of the type of press and the quality of seeds at hand (Remacle, 2005). As a matter of fact, depending of the press, we can have residues with oil content ranging between 15 to 20% (Beerens, 2007; Karaj and Müller, 2011).

To obtain good efficiency, we must apply appropriate great pressure which in turn increases the operating temperature (Singh *et al.*, 2002; Zheng *et al.*, 2005). Then, good extraction process implies a tradeoff between quality and efficiency. The seeds quality may have great influence on both the efficiency and the quality of the extracted oil (Heller, 1996; Williams, 1997; Ratre, 2004). Many tests were conducted on the evolution of the growth of *Jatropha curcas* seeds function of storage time (Ellis *et al.*, 1985; Ratre, 2004). Unfortunately, no test has been done on the influence of seeds storage time on the extracted oil quality. Hence, in this investigation we have studied the influence of storage time on both the seeds and its extracted oil qualities. We have also analyzed the energy production efficiency based on the possible utilization of *Jatropha Curcas* oil as diesel motor fuel.

MATERIALS AND METHODS

Biological materials: Seeds utilized in this study vary according to their age, storage conditions and origin, from Mali and Burkina Faso. They are separated in four specimens Mali G1 (two years of storage time), G2 (one year of storage time), Burkina Faso G3 (two years of storage time), G4 (one year of storage time).

Extraction:

Extraction from solvent: The method utilized is the French standard (NF V03-905). Weight of (5) g of

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seeds are grounded and introduced into an extractor of Soxhlet type equipped at its base with one liter vessel filled with two hundred (200) mL of hexane for (6) h. After the process, the oil is separated from the solvent. Its content expressed in percentage by mass is given by:

$$\text{Th}\% = (m) * \frac{100}{E} \quad (1)$$

where,

Th = The oil content

E = The mass of the concerned specimen

m = The mass of recuperated oil

Mechanical extraction: The pressure is applied at atmospheric temperature (28-30°C) utilizing a Sundhara press from India with 70 to 80 kg/h capacity, equipped with an electric motor and speed regulator. The rotational speed of the screw is set to 20 rpm. For the filtration, a disc screen of 5 μ hole is utilized. The oil production efficiency and the rate of recovery are expressed in the following:

$$\text{Rh}\% = (\text{Mh}/\text{Mg}) \times 100 \quad (2)$$

$$\text{Tr}\% = 1 - [(\text{Rh}/(1 - \text{Rh})) / (\text{Th}/(1 - \text{Th}))] \quad (3)$$

where,

Rh = The oil production efficiency

Tr = The rate of recovery

Th = The oil content

Mh = Oil mass

Mg = Seeds mass

Oil chemical analysis: In this investigation, oil is analyzed for its qualities based on DIN V 51605 standard with the aim of possible utilization as diesel motor fuel. The entire process is done according to the French standard (AFNOR, 1984): acidity (NF T60-204), water content (NF T 60-225), rate of phosphorus (NF T60-227) and rate of sediment (NTF 60-202).

Energy efficiency: The energy efficiency is calculated based on the following expression (ADEME/DIREM *et al.*, 2002):

$$\text{Re} = \frac{\text{Er}}{\text{Enr}} \quad (4)$$

where,

Re = The energy efficiency

Er = The useful energy

Enr = The non renewable energy utilized for growing the *Jatropha* tree

RESULTS AND DISCUSSION

Influence of storage time on the seeds quality:

Influence of storage time, water content and origin on the seeds oil content: The analysis of the results contained in Table 1 shows that the oil content is

Table 1: Influence of storage time on the seeds quality

Specimens and Age (Year)	G1	G2	G 3	G 4
	2	1	2	1
Water content (%)	7.15	6.61	5.68	4.84
Oil content (%)	25.32	31.77	33.42	40.42
Acidity (%)	2.83	1.73	2.63	1.13

Table 2: Extraction at atmospheric temperature

	Specimen 1	Specimen 2
Screw rotation	1	1, 5
Extraction residue average	83.80	87.60
Temperature (°C)		
Oil average Temperature (°C)	70.06	71.62
Non filtered oil efficiency (%)	32.52	34.86
25 μ m filtered oil efficiency (%)	21.29	22.62
Rate of sediment (%)	11.23	12.24
Rate of recovery (%)	77.93	81.40
Mass flow rate (kg/h)	28.24	33.33
Specific mechanical energy (Wh/kg)	75	70

function of the origin of the seeds; the two first specimens from Mali have less oil content than those harvested in Burkina Faso. These results are similar to those obtained from Benin and Togo (Kpoviessi *et al.*, 2004), Madagascar and India (Kaushik *et al.*, 2007) and Congo (Nzikou *et al.*, 2009; Augustus *et al.*, 2002). These differences can be explained by the. The oil content decreases with the increase of the seeds age and water content, the smallest value obtained is 25.32% (G1). On the other hand, the higher oil content, 40.42%, is obtained with the specimen (G4) which has the smallest water content and the shortest storage time (one year). The above results indicate that the seeds must be stored with minimum water content and reduced period of storage time (Ratree, 2004).

Influence of age and water content on the seeds

acidity: As shown, the acidity varies from 2.83 to 1.13%. The highest acidity is obtained with seeds having the maximum water content and longest storage time. The reason of this increase may be the hydrolyze reaction which is favored by the presence of enzyme, the lipase and the seeds moisture. The results obtained by the two specimens of one year storage time are comparable to those published by Abulude *et al.* (2007), Bereens (2007) and Kpoviessi *et al.* (2004) with dried and pretreated rice seeds.

Press tests results analyses: The results of Table 2 show that the seeds residue and the oil increase with the increase of the numbers of screw rotations. The temperature increase (3.8°C) induces the extracted (2.34%) and the filtered (1.33%) oils efficiencies and the rate (3.47%) of oil recovery. This can be explained by the fact that the temperature increase destroys the lipid droplets cells and reduces the oil viscosity which allows it to flow through the cells pores (Wiesenborn *et al.*, 2001; Singh *et al.*, 2002); the mass flow rate (5.09 kg/h) also increase with the temperature increase. As a matter of fact, the regime is more stable when the press temperature increases and therefore the mass flow rate increases as well. Besides, the mass flow rate

Table 3: Oil chemical characteristics

Parameters	Water content (ppm)	Acidity (% m/m)	Phospholipids content (ppm)	Sediment content (% m/m)
Decanted oil 1	1271.15	7.06	300.32	0.0660
Decanted oil 2	1194.77	7.31	312.46	0.0670
Filtered oil 1	1076.01	7.12	200.30	0.0160
Filtered oil 2	966.16	7.22	201.89	0.0140
Seeds	7.15	2.83	-	-
DIN and ASTM Standards	0.075	2.00	312	0.0024

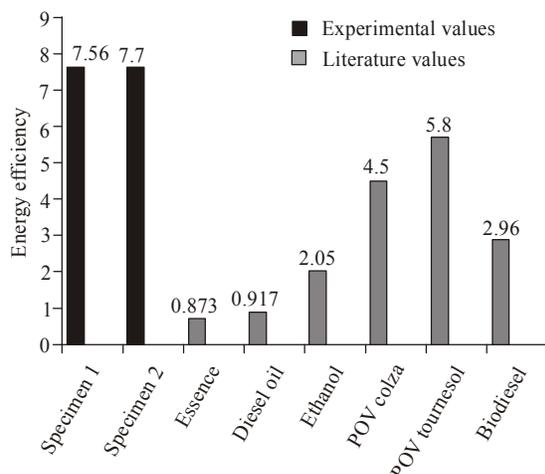


Fig. 1: Histogram of energy efficiency

increase inversely shortens the press work time and its specific energy (5 Wh/kg).

Analysis of oil quality:

Acidity: The results shown in Table 3 indicate that the acidity of the four oils is greater than 2% which is the limit of the DIN V 51605 standard; hence, these oils have high acidity due to the press temperature increases which favors triglycerides hydrolyze reaction leading to the formation of free fatty acid altering the oil quality (Alais *et al.*, 2008). However, these results are greater than those of Kratzeisen and Müller (2009).

Sediments rate: Sediments rate of extracted, decanted and filtered oils are high and are not conform to the biofuel oil specifications (0.0024%). However, the values obtained for filtered oil (0,016% and (0,014%) remain below the values of decanted oil 0,066%-0,067%). These differences in sediments rate can be explained by differences of the oils 'chain of treatments.

Water content: The water content of the specimens is above the maximum water content (0,075%) of biofuel. For decanted oil, the average values are comprised between 0.12% and 0.13% while for filtered oil, the values are between 0.10% and 0.11%. We notice a little decrease of water content after filtration. This is due the hygroscopic nature of the filter material. It is obvious that the water content is function of the seeds humidity (7.15%).

Phospholipids Content (PLC): The oil phospholipids content, measured by the rate of phosphorus, indicates a large variation, function of the oil treatment level. The values obtained for the crude oil are more close to the values of pure oil with a maximum of 312 ppm. The value of the PLC of the filtered oil is even below the phosphorus measurable value. These small values are certainly due the fact that oil is extracted at atmospheric temperature. Let us say that one additional raison is that the trituration temperature is less than 100°C; otherwise, higher temperature favors the liberation of phospholipids contained in the seeds cells pores. The actual values are indeed smaller than those published by Kratzeisen and Müller (2010).

Energy efficiency: The Fig. 1 shows that the energy efficiency of jatropha Pure Vegetal Oil (PVO) is slightly greater than that of colza and turnsole. This can be explained by the differences in the amount of energy consumed during the respective plant growth. One can also notice that the POV of jatropha, turnsole and colza are greater than those of biodiesel and ethanol from sugar beet. This is due to the fact that biodiesel is penalized by the additional energy needed for the esterification reaction, but it becomes compatible with industrial diesel. Globally, biodiesel as renewable energy shows better energy balance than fossil fuel (Fig. 1).

CONCLUSION

The results of the actual investigation show the influence of age, humidity and origin on the seeds oil content. The lower oil content (25.32%) is obtained with older and high water content seeds. In the same way, the acidity content is in correlation with the water content and age. The analysis of extracted oil indicates that the press temperature largely influences the oil quality. The best rate of recovery (81.4%) is obtained with a specific mechanical energy equal to 70 Wh/kg. The POV of jatropha shows better renewable energy balance compared to other biofuels and fossil fuels.

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REFERENCES

- Abulude, F.O., M.O. Ogunkoya and R.F. Ogunleye, 2007. Storage properties of oils of two Nigerian oil seeds *Jatropha curcas* (physic nut) and *Helianthus annuus* (sunflower). *Am. J. Food Technol.*, 2(3): 207-211.
- ADEME/DIREM, Ecobilan and Price Waterhouse Coopers, 2002. Bilans énergétiques et gaz à effet de serre des filières de production de biocarburants en France. Note de Synthèse, Paris.
- AFNOR, 1984. Norme NF V59-107. Recherche des spores de Clostridium perfringens. Technique du nombre le plus probable après incubation à 46 °C. Association Française de Normalisation, Paris.
- Ajibola, O.O., S.O. Adetunji and O.K. Owolarafe, 2000. Oil point pressure of sesame seed. *IFE J. Technol.*, 9(1-2): 57-62.
- Alais, C., G. Linden and L. Miclo, 2008. *Biochimie Alimentaire*. 6e Edn., Dunod, Paris.
- Augustus, G.D.P.S., M. Jayabalan and G.J. Seiler, 2002. Evaluation and bioinduction of energy components of *Jatropha curcas*. *Biomass Bioenerg.*, 23: 161-164.
- Berrens, P., 2007. Screw-pressing of *Jatropha* seeds for fueling purposes in less developed countries. M.Sc. Thesis, Eindhoven University of Technology.
- Ellis, R.H., T.D. Hong and E.H. Roberts, 1985. *Handbook of Seed Technology for Genebanks*. Volume I. Principles and Methodology, IBPGR, Rome, Italy, pp: 220.
- Heller, J., 1996. Physic nut, *Jatropha curcas* L. International Plant Genetic Resources Institute, Rome, Italy, ISBN 92-9043-278-0.
- Henning, R., 2003a. The *Jatropha* Booklet-a Guide to the *Jatropha* System and its Dissemination in Africa. A Guide to *Jatropha* Promotion in Africa. BaganiGb, Rothkreuz 11, D-88138 Weissensberg, Germany.
- Johnson, L.A. and E.W. Lusas, 1983. Comparison of alternative solvents for oils extractions. *J. Am. Oil Chem. Soc.*, 60: 229-242.
- Karaj, S. and J. Müller, 2011. Optimizing mechanical oil extraction of *Jatropha curcas* L. seeds with respect to press capacity, oil recovery and energy efficiency. *Ind. Crop. Prod.*, 34(1): 1010-1016.
- Kaushik, N., K. Kumar, S. Kumar, N. Kaushik and S. Roy, 2007. Genetic variability and divergence studies in seed traits and oil content of *Jatropha (Jatropha curcas L.)* accessions. *Biomass Bioenerg.*, 31(7): 497-502.
- Kpoviessi, D.S.S., G.C. Accrombessia, C. Kossouoh, M.M. Soumanou and M. Moudachirou, 2004. Propriétés physico-chimiques et composition de l'huile non conventionnelle de pourghère (*Jatropha curcas*) de différentes régions du Bénin. *CR. Chim.*, 7: 1007-1012.
- Kratzeisen, M. and J. Müller, 2009. Influence of free fatty acid content of coconut oil on deposit and performance of plant oil pressure stoves. *Fuel*, 89(7): 1583-1589.
- Kratzeisen, M. and J. Müller, 2010. Prediction of deposit formation during combustion of *Jatropha* oil from standard quality parameters. *Fuel*, 89: 2769-2774.
- Nzikou, J.M., L. Matos, F. Mbemba, C.B. Ndangui, N.P.G. Pambou-Tobi, A. Kimbonguila, Th. Silou, M. Linder and S. Desobry, 2009. Characteristics and composition of *Jatropha curcas* oils, variety congo-brazzaville. *J. Appl. Sci. Eng. Technol.*, 1(3): 154-159.
- Ogunwole, J.O., J.S. Patolia, D.R. Chaudahary, A. Gosh and J. Chikara, 2007. Improvement of the quality of a degraded entisol with *Jatropha urcas* L. under an Indian semi arid conditions. Proceeding of Fact Seminar on *Jatropha curcas* L. Agronomy and genetics, March 26-28, Fact Foundation, Wageningen, the Netherlands.
- Oyinlola, A. and L.O. Adekoya, 2004. Development of a laboratory model screw press for peanut oil expression. *J. Food Eng.*, 64: 221-227.
- Ratree, S.A., 2004. A preliminary study on Physic nut (*Jatropha curcas* L.) in Thailand. *Pak. J. Biol. Sci.*, 9: 1620-1623.
- Remacle, M.S., 2005. L'huile végétale brute de pression à froid. ValBiom, Paris (France).
- Rijssenbeek, W.H.R., R. Jongschaap, H.J. Lutzeyer and P. Venturi, 2007. Expert Meeting *Jatropha*. Brussels07/12/07. Brussel.
- Sayyar, S., Z.Z. Abidin, R. Yunus and A. Muhammad, 2009. Extraction of oil from *Jatropha* seeds optimization and kinetics. *Am. J. Appl. Sci.*, 6: 1390-1395.
- Singh, K.K., D.P. Wiesenborn, K. Tostenson and N. Kangas, 2002. Influence of moisture content and cooking on screw pressing of crambe seed. *J. Am. Oil Chem. Soc.*, 79: 165-170.
- Wiesenborn, D., R. Doddapaneni, K. Tostenson and N. Kangas, 2001. Cooking indices to predict screw-press performance for crambe seed. *J. Am. Oil Chem. Soc.*, 78: 467-471.
- Williams, M.A., 1997. Extraction of Lipids from Natural Sources. In: dans Gunstone, F.D. (Ed.), *Lipid Technologies and Applications*. Marcel Dekker, Inc., New York.
- Zheng, Y.I., D.P. Wiesenborn, K. Tostenson and N. Kangas, 2005. Energy analysis in the screw pressing of whole and dehulled flaxseed. *J. Food Eng.*, 66: 193-202.