

Research Article

Mechanical Screw-press Extraction of *Jatropha curcas* Seed Oil in Senegal: Process Description and Feasibility Assessment

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Abstract

Faced with the increasing effects of climate change, the development of resilient plants adapted to arid environments, such as *Jatropha curcas*, is a strategic priority to meet the energy needs of drylands. This plant is used for its valuable oil content and its ability to offer an alternative to fossil fuels in the context of global warming. In Africa, traditional vegetable oil extraction often involves the use of plants in the manufacturing process. This study is devoted to a mechanical pressing of *Jatropha curcas* seeds, harvested in the Fatick region of central Senegal, in order to optimize its oil, using a screw press at 50°C. After hulling, washing and drying, the seeds were carefully selected and introduced into a twin-screw extruder. After 24 hours of settling, the *Jatropha* oil was filtered and then stored in clean, dry containers. The extraction rate obtained, estimated at 10.86%, reveals that this technique is significantly less productive than chemical extraction by Soxhlet, which achieves a yield of approximately 25%. However, its main advantage lies in the superior quality of the oil produced: it is completely free of chemical residues, making it particularly suitable for sensitive applications. Indeed, this oil can be used directly, without a refining step, as biofuel in diesel engines, and it is also a prime raw material for soap manufacturing.

Keywords

Jatropha, Extraction, Mechanics, Oil

1. Introduction

Since 2007, Senegal has focused on promoting *Jatropha curcas*, known locally as “Pourghère” in French and ‘Tabanani’ in Wolof (the local language of Senegal). This wild, non-food plant has several uses, including biofuel production [1]. *Jatropha* hedgerows are used to demarcate fields, preventing stray animals from accessing them and combating wind erosion. Its leaves can

be used as an herbal tea to treat certain infections, and its sap is used to treat wounds. Extensive research on *Jatropha curcas* highlights its potential beyond biofuels, encompassing its medicinal properties [2], pest control, and various industrial applications. The seeds of these *Jatropha* species contain an oil [3] that can be used in biodiesel production, which has

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generated considerable interest for energy purposes [4]. The press cake from pressed *Jatropha* seeds is a high-value organic fertilizer comparable to chicken manure. The applications of vegetable oils depend on the type of oilseed from which they are extracted and the extraction method used. This study reports a mechanical extraction method for *Jatropha* oil using screw presses. Mechanical extraction by pressing [5] represents a promising approach for obtaining vegetable oils, particularly those from oilseeds such as *Jatropha curcas*, due to its efficiency and reduced environmental footprint compared to conventional methods. To make use *Jatropha* seeds, the extracted crude oil is filtered and used directly as fuel in diesel engines without any further processing [6], unlike other biodiesels derived from oilseed crops such as castor and cotton, which are blended with conventional diesel. This allows for the diversification of energy

sources and opens up new economic opportunities, particularly for the cosmetics industry.

2. Materials and Methods

Traditionally used for its medicinal properties, this inedible oilseed plant is attracting increasing interest due to its ability to grow on marginal soils and its substantial oil yield, making it a promising alternative to fossil fuels. The choice of *Jatropha* as a priority species is justified by the fact that its seeds contain a high-energy oil with properties comparable to those of diesel [7]. Furthermore, this plant is undemanding and provides a range of products and benefits that promote integrated rural development.

2.1. Plant Material

2.1.1. Origin of Samples



Figure 1. Geographical location of the region from Fatick (Foundiougne).

The genus *Jatropha* belongs to the Euphorbiaceae family [8] and the Crotonoideae subfamily. It is a branching shrub that can reach 2 to 10 m in height with smooth bark and thin green leaves. It grows naturally, mainly in the central regions (Diourbel, Kaolack, Fatick) (Figure 1) and the southeastern regions (Tambacounda, Kolda, and Casamance).

This study was conducted with *Jatropha* oil producers in the Fatick Region (14° 20' 28" N, 16° 24' 51" W), specifically in Foundiougne, an area located in the peanut basin of Senegal. The population numbers 908,858 inhabitants out of a total Senegalese population of 18,032,473 inhabitants [9]. *Jatropha*

vegetable oil is used in biodiesel production, particularly for its combustible properties. It is a commonly used oil in the formulation of biofuels such as biodiesel [10]. The climate is of the Sudano-Sahelian type with rainfall varying between 600 and 900 mm in normal years.

A social enterprise called SOPREEF, an energy and water production company in the Foundiougne Department, has been operating in the heart of the town of Sokone since 2008. This Senegalese initiative is part of a broader effort to promote local resources through the production of natural vegetable

oils. *Jatropha* oil, which is not edible, has been used in a sustainable cosmetics sector in close collaboration with rural communities for over 15 years. It can also be used as a biological pesticide due to its insecticidal properties [11]. The presence of this company in the study area is an advantage for this research.

2.1.2. Harvesting and Pulping the Fruit

Harvesting is one of the key factors in the economic feasibility of *Jatropha* oil production, as the price of the seeds depends on the harvest time [12]. The duration of ripening and the harvest period vary according to site conditions. They are longer in areas with an extended rainy season. Harvesting lasts approximately two to three months in semi-arid regions, and in areas with a long rainy season, the tree bears fruit year-round. In Foundiougne, *Jatropha* fruit ripens between September and November. Harvesting takes place when the fruit changes from green to yellow and then to brown (Figure 2).

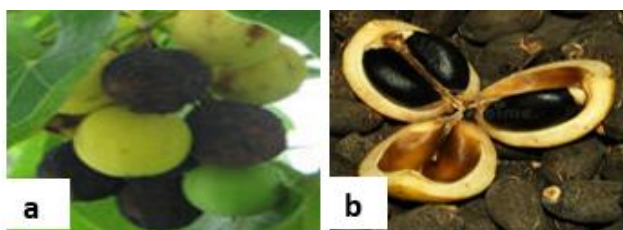


Figure 2. a) evolution of the fruit, from green to brown; b) *Jatropha* seeds.

Harvesting is done by picking the fruit directly from the tree, or, when the tree is too large to reach its upper parts, by knocking the fruit down with a stick. The fruit consists of capsules that, once ripe, open to release seeds. Depulping can be done manually or mechanically and involves extracting the seeds from the pulp. The manual method consists of hitting the dried fruit with a stick, or some producers cover the fresh fruit with plastic wrap to cause the pericarp to rot, then crush the pulp by trampling and spread it out in the sun. The mechanical method, which is not widely used, involves using a manual cone depulper and a sieve for separation.

Dehulling is the process of separating the seed coat, rich in membrane components (cellulose, tannins), from the kernel, which contains most of the useful nutrients (proteins, lipids). Here, hulling the seeds is not mandatory as it can be too time-consuming and doesn't significantly impact the extraction. Dried under optimal conditions, the black seeds can retain their viability for at least a year.

2.1.3. Seed Sorting

Separation then continues by winnowing and sieving. After threshing, winnowing uses a blast of air to separate the lighter parts from the heavier seeds (Figure 3). Sorting is also often necessary to remove residual hulls or sand, as shown in the

Figure below.



Figure 3. Seed sorting device before pressing.

2.2. Extraction: Pressing of Seeds

There are two methods for extracting oils: mechanical extraction by pressing and chemical extraction using an organic solvent. Mechanical extraction is carried out using presses. The most common presses are screw presses, which consist of a perforated cylindrical body in which a conical worm screw rotates and compresses the seeds placed between the body and the screw. The pressing system is powered by a controlled-current electric motor, in this case 17 amps (Figure 4a). At the end of this system, there is also a heating element to slightly warm the seeds before pressing.



Figure 4. Worm screw press machine (a, b) and *Jatropha* cakes (c).

Pressure increases along the screw due to the progressive reduction in volume, forcing the oil to flow out of the body through the designated spaces (Figure 4b). The press cake is collected at the end of the screw (Figure 4c). This process yields a pure oil, free of any foreign substances, after decantation and filtration. Yields depend on the type of oilseed used and the performance of the press. The yield of mechanical extraction is lower than that of chemical extraction. However, the oil obtained is free of solvent traces and has a longer shelf life.

The oil extraction yield is determined using the following formula:

$$\eta = \frac{m_o}{m_s} \times 100$$

η being the yield in%; m_o the oil mass in gram and m_s the seed mass in gram.

2.3. Oil Purification Process

The oil is first decanted for a few days to a month in opaque, chemically neutral tanks. This process allows for the cost-effective removal of certain impurities, which settle to the bottom of the tank. Decantation should not be carried out in metal tanks, for example, because phospholipids bind to metals and catalyze acidification reactions in the oil.

After decantation, the oil is either filtered through a funnel fitted with a very low-porosity fabric or by a mechanical process (pump + filtration system). It is preferable to filter at a low temperature (14°C) because waxes crystallize and are easily trapped (waxes are impurities that cause problems in cold engines). However, the viscosity of the oil can make filtration difficult when the temperature is too low. Filtration removes solid or excessively viscous particles carried over during pressing. In Foundiougne, simple filtration is used for medium quantities of oil, and mechanical filtration for large quantities, with filter pores on the order of micrometers (Figure 5). Regardless of the technique used, contact with air and light must be as brief as possible. These two factors accelerate the oxidation and acidification of the oil.

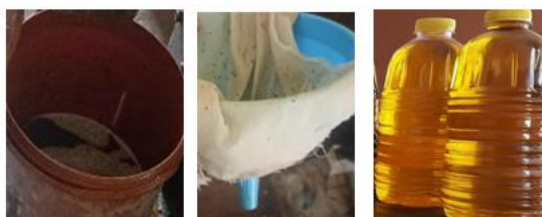


Figure 5. Oil filtration process after decantation.

2.4. Soap Manufacturing Process Using Pure Vegetable Oil (PVO) by the Company SOPREEF

The procedure for producing soap from *Jatropha* oil is described below in the order of the protocol. Three (3) liters of oil are used.

To do this, add 2 kg of caustic soda to a bucket initially containing 5 liters of drinking water, stir to homogenize and wait for the mixture to cool to about 30°C. Next, melt 3.5 kg of shea butter in a saucepan for at least 40 minutes, then add 3 liters of *jatropha* oil. Finally, add a little lemon juice to reduce the shea butter scent. Gradually add the caustic soda solution to the oils, stirring continuously with the wooden spatula, until the solid trace appears. The soap thus formulated is packaged in molds and left to dry for approximately two weeks.

3. Results and Discussion

3.1. Crude Oil Percentage

Mechanical extraction of oil from *Jatropha* seeds yielded

10.86%. Three (3) liters of this oil produced 3.5 kg of soap. *Jatropha curcas* seeds, although rich in crude protein, also contain toxic substances. Among these, phorbolsters, thermolabile and fat-soluble compounds [13], have been identified as the main agents responsible for toxicity. The *jatropha* oil is non edible and cannot compete with food. These molecules, derived from bioactive diterpenes, exert various deleterious effects at the cellular level [14]. Other antinutritional factors are also present, including trypsin inhibitors, lectins (curcin), tannins, saponins, and phytates. These compounds must be eliminated or reduced to non-toxic concentrations to allow for the safe use of the oilseed cake, particularly in animal feed [15]. The principles governing mechanical pressing are its efficiency and its environmental implications compared to solvent extraction methods [16]. The characteristics observed in the oil obtained from *Jatropha* seeds harvested in Senegal are similar to those reported in other studies. *Jatropha* oil is yellow. Its color turns reddish upon heating or prolonged exposure to air [17]. Its odor depends on the extraction process and its age; its flavor is sweetish and its taste is similar to that of castor oil. These characteristics are linked to the oil's composition of triglycerides and fatty acids. Its viscosity is much higher than that of diesel fuel, which makes the use of *Jatropha* oil more difficult in direct injection engines [18].

Its use as a fuel in hot climates should not pose a problem, unlike palm or coconut oil, which must be heated. The flash point of *Jatropha* oil is 236°C. This is the temperature at which the vapors ignite in the presence of a flame. Well above diesel fuel or rapeseed methyl ester, *Jatropha's* flash point is among the lowest of all vegetable oils. The somewhat low yield of 10.86% [19] indicates that some of the oil (approximately 3%) remains in the press cake, but this method remains optimal as it offers better oil quality and is therefore well-suited for biodiesel and soap production. This paradigm shift is primarily driven by increasing regulatory control over solvent residues in food products and by a growing consumer preference for "green" extraction technologies that minimize environmental impact and improve product purity [20].

However, recent innovations have increasingly focused on integrating sustainable and intensified techniques, such as twin-screw extrusion, to improve efficiency and reduce the environmental footprint of oil extraction processes [21]. Recent research has highlighted the high oil content of *Jatropha* seeds, ranging from 20 to 60% for the whole seed and 40 to 60% for the kernel, positioning it as a promising renewable resource for biofuel production [22]. Biodiesel has been produced from *Jatropha* (*Jatropha curcas*) seed oil available in Bangladesh. The mechanical pressing yield was 24.87% [23]. The high free fatty acid content of crude *Jatropha* oil led to acid esterification and basic transesterification for biodiesel production.

The growing demand for fossil fuels, the scarcity of oil, the depletion of energy resources [24], and environmental protection are unavoidable challenges that must be rigorously addressed in the coming decades to ensure the sustainability of

humanity and other living beings. The use of alternative, renewable, biodegradable, economical, and environmentally friendly fuels would reduce fuel demand and contribute to mitigating climate change [25]. Biofuel production currently plays a leading role. The term "biofuels" generally refers to fuels derived from living matter, whether animal or plant. Among high-performing biofuels, biodiesel represents a promising alternative to diesel engines. Renewable, environmentally friendly, safe to use, biodegradable, and with multiple applications, biodiesel has become a major focus of global research and development in the field of alternative energies. Biodiesel from *Jatropha curcas* represents a sustainable alternative to fossil fuels due to its inedible nature and its adaptation to marginal lands [26].

3.2. Advantages of the Pressing Method

Mechanical extraction is a method better suited to rural communities because it is simple and accessible. It offers advantages such as the direct use of *Jatropha* oil in diesel engines [27], even without refining, while preserving its properties. The mechanical method offers local economic opportunities by manufacturing soap from the oil, as well as producing useful by-products such as fertilizer from the oilcake. The challenge is to have a production chain whose investment is sustainable for oil mill projects and which produces pure vegetable oil of satisfactory quality.

From an environmental and social perspective, this method is more advantageous than the chemical Soxhlet method [28]. Indeed, the latter has high energy consumption, pollutes by emitting toxic volatile compounds, and also requires staff training in the use of hazardous products.

3.3. Drawbacks of the Pressing Method

Mechanical extraction using a screw press, with a yield of 10.86%, is less productive than solvent extraction (using a Soxhlet press), which offers a yield that can reach approximately 20% [29, 30]. The latter is more thorough and is carried out at a moderate temperature, whereas mechanical pressing releases heat that can alter the quality of the oil. *Jatropha* oil contains around 80% unsaturated fatty acids (oleic and linoleic acids in similar quantities) and the remainder saturated fatty acids (palmitic and stearic acids) [5]. This high proportion of unsaturated acids tends to make it unstable and facilitates oxidation and acidification.

4. Conclusion

A mechanical extraction method of *Jatropha C.* seed oil was carried out in this study. Three major fractions were obtained: seed oil, shells and cakes. Overall, it shows that mechanical extraction using a screw press has a relatively low oil yield, compared to solvent extraction. The organic solvent extraction technique (Soxhlet) provides a better yield, but has drawbacks

related to environmental pollution and also to oil quality due to solvent residues. In addition, this cold extraction process made it possible to obtain a virgin oil that retains all the bioactive substances sought in fuels, soaps and other lubricants. Dried shells are often used as an excellent source of energy. *Jatropha* press cake is a valuable residue due to its high protein and mineral content. It can be used as organic fertilizer or compost to enrich the soil. This cold pressing method is very accessible to rural populations because it requires only a modest investment in equipment and simple vocational training. It promises circular economy, thanks to the valorization of all by-products, and could be better implemented with the aim of improving oil and oilseed meal yields.

Abbreviations

NASD	National Agency of Statistics and Demography of Senegal
PVO	Pur Vegetal Oil
SOPREEF	Society for the Promotion of Access to Energy and Water in the Department of Foundiougne

Author Contributions

Djibril Diouf: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing

Edmond Antoine Badock: Conceptualization, Investigation, Project administration, Writing – original draft, Writing – review & editing

Samba Fama Ndoye: Conceptualization, Formal Analysis, Supervision, Validation, Visualization

Omar Thiam: Data curation, Investigation, Visualization, Writing – original draft

Anna Ndiaye: Data curation, Formal Analysis, Visualization, Writing – original draft

Abdoulaye Dramé: Data curation, Formal Analysis, Investigation, Visualization, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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