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Characterization of the Extracted Oil by Screw Press from Egyptian Jatropha Seeds

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A B S T R A C T

Increase of fossil fuel consumption rate, depletion of conventional fuel, harmful pollutants increase, and global warming contribute to search about alternative fuels. The produced oil from non-edible jatropha seeds becomes the researcher's interest due to the higher price of edible oils. An efficient system for extracting the oil from Egyptian jatropha seeds has been designed, manufactured and tested. The designed screw press was to get the highest oil yield. Physical and chemical characteristics such as the extracted oil density, kinematic viscosity, flash point, heating value and cetane number were calculated. The extraction time of the oil from jatropha seeds was 30 minutes at a yield of 19%. Due to lower FFA of 2.7%, the extracted jatropha oil provided light color. As the temperature decreased, the density and viscosity of the extracted oil were decreased. The produced oil flash point was greater than crude diesel. The extracted jatropha achieved the calorific value of 39128 kJ/kg. Screw press extraction process increased jatropha biodiesel oxidation instability due to the content of oleic and linoleic acids.

1 Introduction

Because of the fuel shortage and global warming, there is an intensive search about alternative fuels. Jatropha plants are cultivated in sewage bonds and desert. Jatropha oil extraction may be achieved either by chemical or mechanical presses. Biodiesel has become environmentally friendly since it is obtained from renewable resources, in addition to its benefits [1,2].

Various types of oil expellers were used for jatropha oil extraction. Sundhara and Komet expellers were utilized. Extraction of jatropha oil was performed mechanically, chemically and enzymatically. The mechanical press prototype was of cast iron heavy parts and iron sheets. The mechanical press was driven electrically. In rural areas, the produced oil from the seeds using conventional manual methods. A single screw mechanical expeller was used as Komet expeller. Chemical methods were used for oil extraction like aqueous enzymatic treatment. Ultra-sonication had been used as an effective method for jatropha oil extraction with higher yield of 74% [3–6].

Soxhlet is used as a reference conventional extraction method. Soxhlet process requires a long time and large amount of solvents. Most extraction processes are simple in construction. Extraction processes which favored to be used widely in industries and laboratories are cheap [7–9]. Mechanical processes followed by solvent can be used in oil extraction from seeds. Soybeans have lower oil content, but sunflower seeds, palm and rapeseed have higher oil contents [10–12].

In solvent extraction, the jatropha curcas seeds pretreatment before oil extraction consume about 24% of the total internal energy and 66% in mechanical extraction. Extraction efficiency in mechanical extraction method is about 96% but solvent extraction is about 79% [13,14]. Biodiesel was produced from jatropha oil. The oil properties such as density, kinematic viscosity, flash point, pour point and cloud point were evaluated for jatropha oil and compared to conventional fossil diesel. Jatropha oil properties allowed to be used in conventional diesel engines, [13,15].

The ram press produced small quantities of the oil in rural areas. The strainer press has more successfully extracted the oil and utilized manual action. The cylinder press extracted the oil in a wide scale from jatropha seeds with oil yield of 89.4%.[16].

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Performance of a screw press for Jatropha seeds extraction was studied under different capacities and seed moisture content. The oil yield, extraction efficiency, specific energy, and operational cost were studied. The highest oil yield and extraction efficiency were 43 kg/hr. and 81%, respectively, [2,17–19].

Jatropha oil was the ideal sustainable and low-cost oil feedstock source for biodiesel production [20]. The expression of oil expression was very sensitive to prepare seeds. A porous solid was performed by the existence of seed shells. The oil expression specific mechanical energy was less than 5% of the oil energy content [21]. Mechanical extraction pressing was carried out on jatropha seeds using twin-screw press [22].

Oil extraction was performed at a compression speed of 0.05–2.5 MPa/s, applied pressure of 5–25 MPa, pressing temperature of 25–105 ^{0}C, pressing time of 1–30 min, and preheating time of 0–30 min. The temperature increase and pressing time enhanced the oil recovery. The optimum recovered oil was obtained when jatropha seeds were pressed at 15 MPa and a temperature of 90 ^{0}C for 10 min of time pressing, [23,24].

Using the pressing vessel diameter of 60 mm, jatropha seeds were pressed under a height of 80 mm. The relation between compressive force and deformation was investigated and the mass of produced oil was measured [24]. At first, the seeds should be crushed to smaller particles of diameter less than 2 mm and preheated at optimization conditions [25].

The literature studies the effect of seed pretreatment on screw pressing of Jatropha oil but little research papers focused on the extraction oil properties. The screw press was selected because of its higher yield. This study aimed to investigate the influence of screw extraction process on fatty acid content, oil yield and oil properties from Egyptian jatropha seeds. The target of this paper is to press Egyptian jatropha seeds with lower cost and local materials by designed and manufactured screw press. The designed screw press was tested. The aim of the screw press is to extract the jatropha oil with higher yield. The selected materials were tested for the applied load. Screw press parts were manufactured for easy maintenance. The produced oil properties of the extracted oil were evaluated to show the effect of the extraction method on physical and chemical properties.

2 . Research Approach and Methodology

The design of screw press relies on Pascal's principle. The system is a press acting as a pump that has humble mechanical force acting over a small cross sectional area. The other part is a press having a larger area that generates a higher mechanical force correspondingly. If the pump is separated from the press cylinder, only small diameter tubing which resists pressure more easily is needed. The pressure on a restricted fluid is transmitted without being diminished and acts with equal force on equal areas at 90^o to the container wall. When the press is pushed internally, the incompressible oil is displaced. The displaced volume by the small press is equal to the displaced volume by the large press. This causes a difference in the displacement which is proportional to the ratio of the press head area. Thus, the small press should be moved a large distance to allow the large press to move significantly. In this study, the applied force increased on the larger press area, the applied force over a distance should be decreased.

Jatropha oil extraction using screw pressing was investigated. A sieve plate covered with fine mesh was used. The pressing chamber has a controlled temperature from 30 to 100 ^{0}C with a fixed diameter. The press pressure is up to 100 MPa. The screw plunger supplied with sensors for temperature, pressure and position measurements. The piston was lowered on the top of the seeds. The seeds were laid in the press chamber then the piston was pressed on the seeds. The pressing temperature can be equilibrated for at least 30 min on the seeds without mechanical pressure which is raised up to 4 MPa for 10 sec. The pressure was extended linearly at the desired speed until it reached to the final pressure. This extraction yield was 10% of the extracted oil, [26].

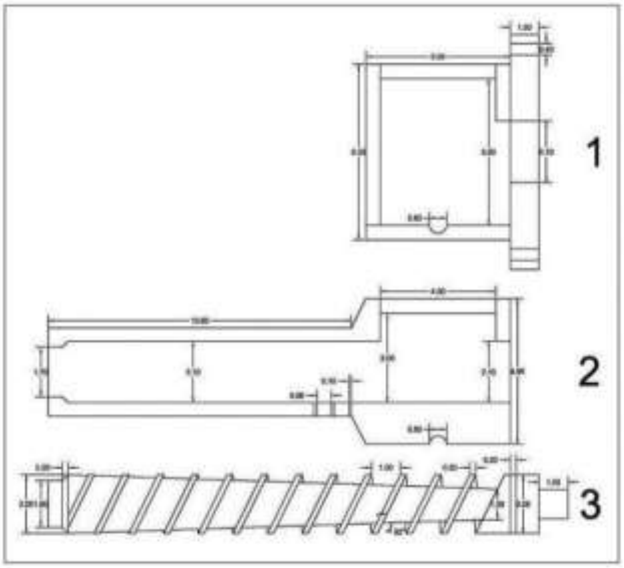
2.1 . Screw Press Design

2.1.1 . Design Considerations

A helical screw mounted on a rotating conical shaft in a cylindrical barrel of the press. The screw moved the fed seed and pressed it toward the discharge as the shaft rotated. The perforations of the barrel were used to discharge the oil. The cake was drained from the unclosed end of the barrel. The oil milling was followed by expressing with a small quantity of milled seed. A seed quantity of 10 kg/hr was satisfied by the performance requirements. The screw press was easy fabricated.

2.1.2 . Screw Press Fabrication

The base, housing and screw are the components of the screw press. Figure 1 showed the screw press components. The supported housing in the assembly contains the screw. The seeds were fed to the rotating screw through the base and housing holes. A hole underneath the housing collected the oil.



(1) Base, (2) Housing and (3) Screw (Dimensions in centimeters).

Figure 1: The main components of the screw press.

Mechanical pressing achieved higher production of the oil from the seeds up to 20%. The extraction process using screw press is continuous because of its higher yield. An electric motor connected with a reduction speed gearbox was used to drive the screw press. A frequency inverter was used the change the rotation speed of the motor. The motor direction was controlled by a control switch. Jatropha seeds were preheated using heaters and a temperature thermostat for temperature control. Figure 2 shows a photograph of the press and associated parts.

1	Motor	2	Gear box	3	Base A
4	Base B	5	Housing	6	Heaters
7	Screw	8	Temp. sensor	9	Hopper
10	Inverter	11	direction switch	12	Thermostat
13	Relay	14	Oil collector	15	Coupling

Figure 2: The screw press photographic view.

2.1.3 . Operation of screw press

The hopper contains the pressed seeds. The screw shaft was driven by an electric motor of 0.37 kW at a variable speed up to 180 rpm. The motor power was transmitted to the shaft through a gear box. The seeds were manually fed into the barrel. The electric heaters were placed on the housing to preheat the meal. The screw moved the seeds into a gap between the barrel and the tapered shaft of the screw. As the milled meal went into through the clearance between the shaft and the housing, the oil was extracted from the housing slits and the cake was pushed out of the housing. The operation was continuous and more seeds can be put into the hopper until enough oil has been produced. The heaters were switched off when the temperature of the meal made the oil to flow.

2.1.4 . The Rotating Tapered Shaft Design

The solid shaft is made of austenitic steel of yield stress 280 MN/m^2 (0.3% C, 18% Cr and 8% Ni). The shaft material density is 7840 kg/m^3 and its length is 0.18 m. The shaft material rigidity modulus is 80 GN/m^2 but the modulus of elasticity is 200 GN/m^2. Rotation of the shaft fixed end related to the shaft free end called twist angle. Maximum permissible angle of twist is one per 300 mm length and the factor of safety is 2.5. The shaft design was based on the maximum shear theory [28, 29].

$$\tau_{max} = \frac{0.5\, S_{yt}}{FS} \quad (1)$$

$$\tau_{max} = \frac{0.5\,(280 \times 10^6)}{2.5} = 56\ MN/m^2 \quad (2)$$

$$\tau_{max} = \frac{16\,T}{\pi d^3} \quad (3)$$

The torsion of a solid circular shaft was evaluated as:

$$\frac{T}{J} = \frac{\tau}{R} = \frac{\theta_t G}{L} \quad (4)$$

From which

$$\tau = \frac{R\theta_t G}{L} \quad (5)$$

The shaft radius of 8 mm is safe for a twist angle of 2° on a length of 0.18 m. The shaft of diameter of 30 mm withstands a stress of 50 MN/m^2.

The applied torque

$$T = \frac{J\theta_t G}{L} = 18.513\ N.m \quad (6)$$

The shaft radius of 8 mm withstands a torque of 18.513 N. m which is higher than the calculated torque of 12.729 N.m. A shaft radius of 13 mm is safe and against failure due to shear stress, toque or tension.

2.1.5 Screw Length

The governing design equations of a wound helix on the tapered shaft are given by:

$$y = (r + mL)\sin\theta,\ z = (r + mL)\cot\alpha,\ x = (r + mL)\cos\theta \quad (7)$$

Where x, y, z are the shaft axes. The length S of the helix curve defined by x, y, z is given by:

$$S^2 = x^2 + y^2 + z^2, \quad (8)$$

According to Hildebrand [27]:

$$\left[\frac{ds}{d\theta}\right]^2 = \left[\frac{dx}{d\theta}\right]^2 + \left[\frac{dy}{d\theta}\right]^2 + \left[\frac{dz}{d\theta}\right]^2 \quad (9)$$

Where:

$$\frac{dx}{d\theta} = (r + mL)\sin\theta \quad (10)$$

$$\frac{dy}{d\theta} = (r + mL)\cos\theta \quad (11)$$

$$\frac{dz}{d\theta} = (r + mL)\cot\alpha \quad (12)$$

$$\left[\frac{ds}{d\theta}\right]^2 = (r + mL)^2[\sin\theta^2 + \cos\theta^2 + \cot\alpha^2] \quad (13)$$

or,

$$\frac{ds}{d\theta} = (r + mL)\,\mathrm{cosec}\,\alpha = \frac{r+mL}{\sin\alpha} \quad (14)$$

or,

$$s = \frac{r+mL}{\sin\alpha}\int_{\theta_1}^{\theta_2} d\theta = \frac{r+mL}{\sin\alpha}(\theta_2 - \theta_1) \quad (15)$$

If $\theta_1 = 0.0°$ and $\alpha = 17°$ then:

$S = 3.4203\,(r + mL)\,\theta_2 = 3.4203\,(r + mL)\,n\pi$ (16)

The screw length S is given by:

$S = 2\pi\,R\,n\sec\alpha$ (17)

The volume of the spiral space between the screw crest and inside the housing can be found as:

$V = B\,S\,h = S\,h\,D\tan\theta$ (18)

But,

M = screw capacity = 10 kg/h and the volumetric flow rate V is given as:

$V = \frac{M}{\rho}$ m^3/h (19)

According to Woodley [28], the screw press input capacity per hour can be found as:

$C = 60\,P\,ANK_m\,K_n\,\rho$ (20)

Where $K_m = 0.35$ and $K_n = 1.0$

N: being varied between 20: 140 rpm for screw

ρ: Is 620 kg/m^3 and

P: pitch of 10 mm.

$$\dot{V} = \frac{M}{\rho} = \frac{10}{620}$$

$V = B \times S \times h = = n\pi^2 D^2 h\tan\alpha\sec\alpha = 1.36 \times 10^4 m^3$ (21)

If h = 4.75 mm,

D = 30 mm,

Helix angle α is the angle between the axis line and the helix (α = 28°). n = 12.

Therefore, the screw length from Eq. (18) equals

S = 1.352 m.

2.1.6 . Tapering Diameter

Tapering angle is the angle between the center axis of shaft and the taper. The tapering shaft diameter and its length at different tapering angles β was shown in Table 1. The base diameter of tapered shaft was chosen according to the mean diameter of the taper ((D+d)/2) = 28 mm).

Table 1: The tapering diameters with its length at different tapering angles β.

Tapering angle, β	m = tan β	Shaft length, L (mm)	mL (mm)	R = r + mL (mm)	D = 2R (mm)
0.5	0.008727	50	0.436	5.686	11.373
		100	0.873	6.123	12.245
		150	1.309	6.559	13.118
		200	1.745	6.995	13.991
		250	2.182	7.432	14.863
1	0.017455	50	0.873	6.123	12.246
		100	1.746	6.996	13.991
		150	2.618	7.868	15.737
		200	3.491	8.741	17.482
		250	4.364	9.614	19.228
1.5	0.026186	50	1.309	6.559	13.119
		100	2.619	7.869	15.737
		150	3.928	9.178	18.356
		200	5.237	10.487	20.974
		250	6.546	11.796	23.593
2	0.034921	50	1.746	6.996	13.992
		100	3.492	8.742	17.484
		150	5.238	10.488	20.976
		200	6.984	12.234	24.468
		250	8.730	13.980	27.960

2.1.7 . Pressure

The expressing pressure was affected by the shaft speed as shown in Table 2. **Adeeko and Ajibola** [29] showed that the expressed oil from the seed was produced at a static pressure not less than 20 MPa. The pressure of 50 MPa at the pressing zone was led to a power transmission efficiency of 40%. The driving speed was varied up to 180 rpm.

Table 2: Effect of shaft speed variation on the pressure (housing diameter = 22 mm, maximum shaft diameter = 20 mm).

Power (kW)	Shaft speed, N (rpm)	Torque, T (Nm)	Force, F (kN)	F Cos α (kN)	x sectional area (x 10-4 m^2)	Pressure (Mpa)
0.1	20	47.746	9.095	8.030	1.13	71.001
	60	15.915	3.032	2.677		23.667
	100	9.549	1.819	1.606		14.200
	140	6.821	1.299	1.147		10.143
	180	5.305	1.011	0.892		7.889
0.2	20	95.493	18.189	16.060	1.13	142.002
	60	31.831	6.063	5.353		47.334
	100	19.099	3.638	3.212		28.400
	140	13.642	2.598	2.294		20.286
	180	10.610	2.021	1.784		15.778
0.3	20	143.239	27.284	24.090	1.13	213.003
	60	47.746	9.095	8.030		71.001
	100	28.648	5.457	4.818		42.601
	140	20.463	3.898	3.441		30.429
	180	15.915	3.032	2.677		23.667
0.4	20	190.986	36.378	32.120	1.13	284.004
	60	63.662	12.126	10.707		94.668
	100	38.197	7.276	6.424		56.801
	140	27.284	5.197	4.589		40.572
	180	21.221	4.042	3.569		31.556
0.5	20	238.732	45.473	40.150	1.13	355.005
	60	79.577	15.158	13.383		118.335
	100	47.746	9.095	8.030		71.001
	140	34.105	6.496	5.736		50.715
	180	26.526	5.053	4.461		39.445

2.1.8 . Specifications of Screw Press and Dimensions

Specifications of the present screw press and dimensions are showed in Table 3.

Table 3: Specifications of the present screw press and its dimensions.

No.	Parameter	Specifications
	Material	Austenitic steel
1	Base diameter of screw, mm	10.5
2	Maximum diameter of screw, mm	20
3	Length, mm	180
4	Angle of taper, Degree	1.5
5	Diameter of housing, mm	30
6	Rotation speed, rpm	0-140
7	Electric motor power rating, kW	0.37
8	Room temperature, °C	300
2	Yield stress, MN/m^2	280
5	Inner diameter of housing, mm	22
12	Pressure, MPa	20 - 50
13	The helix angle, Degree	28°
14	Electric heater, kW	0.5

3 Results and Discussion

3.1 . Analysis of Free Fatty Acid (FFA)

The oil physical and chemical properties depend on the extraction temperature. The applied extraction temperature produced hydrolyzed and oxidized oil. The extracted oil darker color is due to the longer time with higher extraction temperature. Soxhlet extraction process was shown in Figure.3. Higher extraction temperature produced the oxidation process. Soxhlet process extracted darker oil than the solvent, and screw processes. The fatty acid percentage of the extracted oil with different extraction processes was shown in Table 4. The extracted oil color in screw press is light with a minimum FFA of 2.7%. Soxhlet process extracted darker oil with a higher FFA of 21.1 %. The FFA% and oil color was affected by the extraction temperature and these parameters effect on the biodiesel production process.

The percentage of FFA in the oil was determined by titration. NaOH weight of four grams was dissolved in a distilled water of one liter (0.1 NaOH) solution. The end point was get using Phenolphthalein indicator. Jatropha oil of 1 ml was dissolved of pure isopropyl alcohol of 10 ml. The mixture is then warmed and well mixed until the oil in the alcohol dissolves, and the mixture is transparent. Two drops of phenolphthalein have been applied while NaOH has been applied to the oil solution drop by drop. The mixture was mixed for 10 seconds until the mixture transformed to pink color. FFA percentage calculation was evaluated from these formulas [33, 34].

$$FFA\% = (28.2\ t\ n) / w \tag{24}$$

Where:
w = The oil sample weight in grams (1ml = 0.92 g),
t = The titration solution volume in ml, and
n = NaOH solution normality (n= 0.025).

Thus,

$$FFA\% = 0.766\ t \tag{25}$$

The oil color and its quality were affected by the extraction method. The extracted oil color was evaluated by Lovibond scale [2, 33, 34]. Table 5 showed the oil colors produced from different extraction methods. The lighter oil color in Lovibond scale dwindles down with less FFA% and better quality. The extracted oil oxidation depends on the applied extraction temperature and time. The darker color of oil produced from higher screw motor speeds.

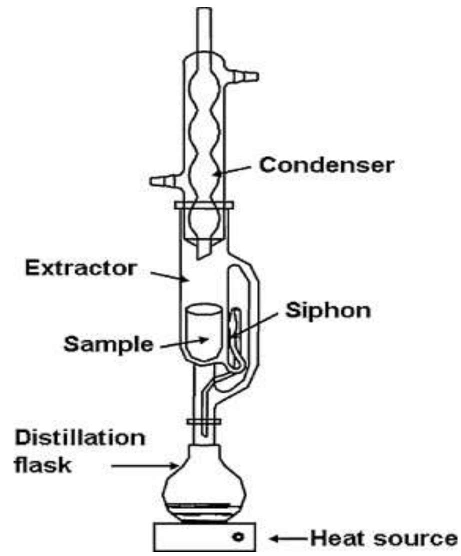


Figure 3: **Soxhlet extraction process**

Table 4: Fatty acid percentage of the extracted oil and its color.

No.	Extraction process	NaOH, ml	FFA, %	Lovibond No.
1	Screw press	3.5	2.7	4
4	Soxhlet	27.5	21.1	24

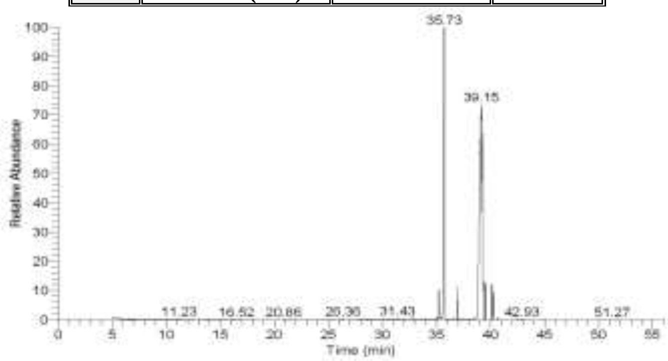
3.1.1 . Gas Chromatography Analysis for Jatropha Oil

This method was used to evaluate the oil fatty acid composition by separation of the mixtures according to their boiling points. Methylation process was used to prepare the oil sample. To obtain methanolic sodium hydroxide, 2 grams of NaOH is dissolved in 100 ml of methanol. Mixing the mixture for 2 minutes had provided the transparent solution of methanolic sodium hydroxide and then the mixture was refluxed for 10 minutes. The sample was mixed with 30 ml of concentrated HCL, 20 ml of methanol and refluxed for 10 minutes, then 10 ml of hexane was added, refluxed for 2 minutes and left to cool. 10 ml of distilled water was added and the mixture was allowed to separate. The collected upper layer was dried by calcium chloride. This sample is ready for GC analysis [33, 34].

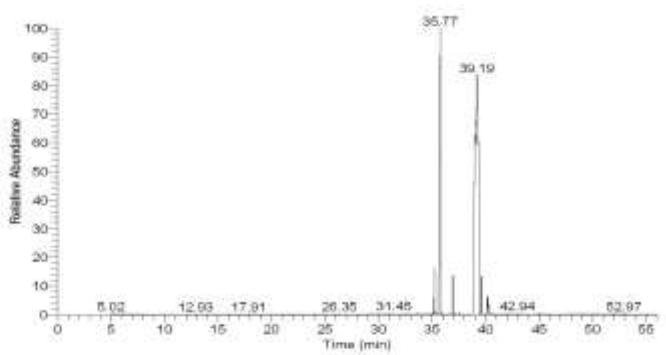
Hewlett Packard model 5890 was used for GC analysis. The retention indices for the different methyl esters of fatty acids were determined using methyl esters of fatty acids (C4-C22), (Sigma Aldrich Co.) as references [34, 35]. There are three main forms of fatty acids found in saturated triglyceride (Cn: 0), monounsaturated (Cn: 1) and polyunsaturated (Cn: 2, 3). Vegetable oils are feedstocks for the biodiesel production and are influenced by the oil composition. Vegetable oil should have lower saturation and poly unsaturation. Oleic, linoleic, palmitic and stearic fatty acids are the principal fatty acids in jatropha oil. The fatty acid content in jatropha oil was seen in Table 5 for different extraction processes. Jatropha oil is oleic–linoleic oil. Jatropha oil has higher percentage of oleic fatty acid about other vegetable oils as shown Fig. 4. The poor oxidation stability of biodiesel was produced in vegetable oils containing linoleic and linolenic acids. At lower temperatures, the higher degree of unsaturation of vegetable oils contributed to poor flow characteristics and higher freezing point. The higher mono unsaturation in jatropha oil made it a good candidate for biodiesel production. Peak values in Fig. 3 showed the related to the time and relative abundance. In this sequence, the oxidation instability of jatropha biodiesel was increased: soxhlet, then screw according to the composition of oleic and linoleic acids. According to palmitic acid content, jatropha biodiesel freezing point increased from screw to soxhlet in ascending order.

Table 5: Fatty acid composition of extracted jatropha oil.

No.	Fatty acid	Screw press	Soxhlet
1	Palmitic (16:0)	25.26	23.83
2	Stearic (18:0)	2.11	0.04
3	Oleic (18:1)	17.09	0.47
4	Linoleic (18:2)	48.15	15.63



(a): Oil extraction by Screw press.



(b): Oil extraction by Soxhlet

Figure 4: GC for oil extraction Methods.

3.2 . Effect of Extraction Process on Extraction Time and Yield

The best extraction method depends on the extraction. Soxhlet extraction process was not a continuous process because the crushed jatropha seeds were mixed with solvent for 4 hrs. Screw press extraction produced a higher yield of the oil up to 20%. The extracted oil from one kg of jatropha seeds needs more than 40 hrs in Soxhlet extraction process. The screw press used 1 kg of seeds in 30 minutes. Table 6 displays the extraction time and yield for the extracted oil. The continuous extraction process gives the least period for extraction. Extraction by the screw press is beneficial as it required less time in extraction but solvent takes more time. The yields for soxhlet and screw oil extraction are 25 and 19%, respectively. Solvent extraction is expensive but screw press is economically and was used in commercial mass production [1, 2]. The oil yield from jatropha seeds can be calculated as [38, 39].

$$\text{Oil yield percentage} = \frac{\text{Weight of oil obtained in gm}}{\text{Weight of seed taken in gm}} \times 100 \quad (26)$$

The consumed energy of the extraction processes was calculated related to the power and time of oil extraction for one kg of jatropha seeds by the following equation:

$$\text{Energy Consumed} = \text{Power} \times \text{Time} \quad (27)$$

The consumed energy in screw press (heater of 500 Watt and electric motor of 370 Watt) is 435 W.hr for the extracted oil from 1 kg seed in 30 min. Soxhlet method contains a magnetic stirrer with heater of 500 Watt driving motor operating for 40 hrs. The solvent is evaporated by a rotary evaporator with 249 Watt electric motor, a vacuum pump of 200 Watt, and a 500 Watt heater in around 1.25 hr. The soxhlet extraction process has a cumulative energy consumption of 21186.25 W.hr/kg. The calculated energy consumption of solvent and soxhlet methods can not consider the chemicals, water and other used materials. The higher yield, minimum time and lowest energy consumption were achieved for screw press method.

Table 6: The extraction time and oil yield of extraction processes.

No.	Extraction process	Extraction time, minutes	Oil Extraction Yield, %	Energy W.hr / kg seeds
1	Screw press	30	19	435
3	Soxhlet	2400	25	21186.25

3.3. Effect of Oil Temperature on Density

The densities values at different temperatures of the extracted jatropha oil by the four methods are shown in Figure 5. The oil extraction temperature has a significant effect on the extracted oil density. The density values provided by the four methods are shown in Figure 5 at different temperature of the extracted jatropha oil. The temperature of oil production has a tremendous impact on the oil density. The densities of jatropha oil at a temperature of 20° C measured by test method ASTM D-1298 are 914 and 909 kg/m^3 for screw and soxhlet, respectively. The oil density decreased with the temperature rise. The density is linearly relation to the oil temperature. The density correlations at different temperatures can be calculated for different methods of extractions. The correlations of density at different temperatures for soxhlet and screw, respectively are ($\rho = -0.5277\ T + 920.38$) and ($\rho = -0.5760\ T + 923.73$).

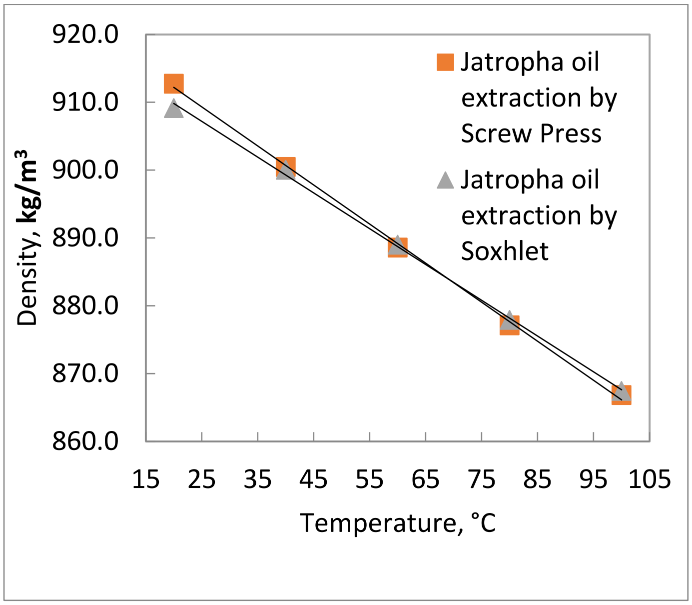


Figure 5: Effect of temperature on the extracted oil density.

3.4. Effect of Oil Temperature on Viscosity

The viscosities of jatropha oil produced by extraction processes at different temperature are shown in Fig.6. Jatropha oil has a greater viscosity about diesel oil. The measured dynamic viscosities of jatropha oil at 40 °C measured by ASTM D-445 are 4.1 and 4.3 cp for screw and soxhlet, respectively. The increase in oil temperature led to the viscosity decrease. Oil preheating decreases the higher oil viscosity in diesel engines. The viscosity of the extracted oil can be correlated and decreased as a power function according to the oil temperature increase. The correlations of viscosity at different temperatures for soxhlet and screw, respectively are ($\mu = 76.562\ T^{-0.806}$) and ($\mu = 76.152\ T^{-0.795}$).

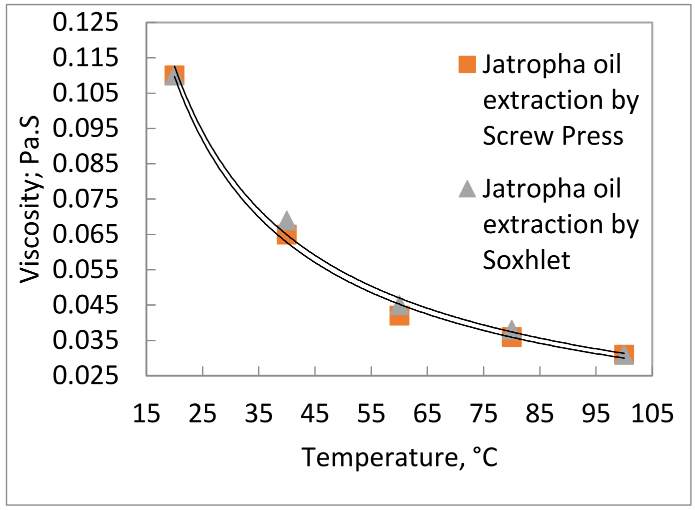


Figure 6: Effect of temperature on the produced oil Viscosity.

3.5. Effect of Extraction Process on Oil Properties

Jatropha oil recorded calorific values of 39135 and 39128 kJ/kg for soxhlet and screw, respectively as shown in Table 7. Calorific value aids in the alternative fuel optimum choice in diesel engine to achieve higher engine performance. Soxhlet, and screw extractions for jatropha oil produced cetane number of 37.53 and 37.83, respectively. Cetane number determines the fuel combustion quality. Lower ignition delay and lower engine performance associated with the higher Cetane number. Jatropha oil flash points for screw and soxhlet extractions are 142 and 140 °C, respectively. Flash point temperature determines the safe handling and storage. Jatropha oil flash point is higher than diesel oil, thus, handling and storage of the oil are less hazard about diesel oil.

Table 7: Measured physical and chemical properties of the extracted oil.

No.	Extraction process	Flash point,°C	Cetane number	Calorific value, kJ/kg
Test Method		ASTM D-92	ASTM D-13	ASTM D-240
1	Screw press	142	37.83	39128
3	Soxhlet	140	37.53	39135
6	Diesel	75	45	42000

3.6. Extraction Method Comparison

Extraction methods are compared based the time of extraction, oil color, yield and FFA%. Cetane number, calorific value, flash point, viscosity, density and fatty acid composition do not influenced by the extraction process. The optimum extraction method can be getting by a compromise. The lighter color, minimum extraction time, fatty acid composition and maximum oil yield are the factors to show the optimum extraction method. The screw press extraction was chosen as the optimum process because of its superiority over other extraction processes as shown in Table 8.

Table 8: Extraction processes comparative analysis.

No.	Extraction method Characteristics	Best	Soxhlet	Screw press
1	Extraction time, min	Minimum	2400	30
2	Extraction yield, %	Maximum	25	19
5	FFA, %	Minimum	21.1	2.7
4	Color, L No.	Lighter	24	4

4 . Conclusions

The vital aim of the research paper is to design, manufacture, and test the screw press to produce the improved properties and higher yield of the produced oil from Egyptian jatropha seeds. The present results led to these conclusions:

1. The extraction oil time is 30 minutes at a yield of 19% from jatropha seeds.
2. Higher extraction temperature caused darker color of the produced oil because of oxidation. The extracted lighter oil color was produced from screw pressing with FFA of 2.7%. This method is characterized for higher oil production .
3. The temperature increase led to the decrease in extracted oil viscosity and density. The fitted correlations of viscosity and density in relation with temperatures were used for the different extraction processes.
4. Extracted jatropha oil flash point by screw press is higher than diesel oil, thus, storage and handling is less hazardous. The extracted jatropha oil calorific value extracted by screw press is 39128 kJ/kg .
5. Jatropha oil contains oleic, linoleic, palmitic and stearic fatty acids. The increase of jatropha biodiesel oxidation instability was due to the oleic and linoleic acids content.

Conflict of Interest

The authors declare no conflict of interest.

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