SCREW PRESS PERFORMANCE FOR OIL EXTRACTION FROM *JATROPHA CURCAS* L. SEEDS OF DIFFERENT MOISTURE CONTENT

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This article describes an extraction experiment conducted to investigate the performance of a screw press oil outlet chamber positions on the amount of oil extracted from *Jatropha curcas* L. seeds of different moisture content. The oil extracted from the jatropha seeds was measured at seven different positions of the screw press. The result showed that maximum amount of oil was produced at the screw press positions 3, 4, 5 and 6; whiles at positions 2 and 7; minimum amount of oil was realized. There was no mass flow of oil at screw press position 1. Also jatropha seeds with low moisture content produced greater amount of oil compared to seeds with high moisture content. Temperature measurement at the screw press positions during the extraction process increased from 20 °C to 68 °C, which suggests that more heat was generated which could have an effect on the oil. In conclusion, it was found out that moisture content and screw press equipment are important factors that could influence the oil output.

screw press; jatropha seeds; jatropha oil; moisture content

INTRODUCTION

Jatropha curcas L. is a large shrub or small tree reaching a height up to 5 meters and belongs to the Euphorbiaceae family. The seeds and oil are not edible due to presence of toxins as phorbol esters, trypsin inhibitors, lectins, phytates (Francis et al., 2005). Two main extraction methods namely mechanical and chemical have been identified for obtaining the jatropha oil (Aderibigbe et al., 1997; Forson et al., 2004). The most common is the mechanical extraction involving the use of an engine driven screw press such as Sundhara press, achieving a yield of 70–80% of the available oil (Henning, 2000; Tobin et al., 2004) or manual presses for example, Yenga or Bielenberg ram press, which can achieve an output oil of 60–65% (Tewari, 2007; Forson et al., 2004; Rabe et al., 2005). Since jatropha oil is essential for production of biofuels, the improvement of extraction methods and the optimization of existing methods have gained relevant attention. This is to discover extraction methods that can extract a greater percentage of jatropha oil from the seeds. Therefore, to optimize oil production when using screw presses there are some factors, which are necessary for considering. Among them is temperature, which is caused by the friction inside the screw press and this generates heat, which is passed on to the oil (Bereens, 2007). The influence of temperature also lowers the viscosity of the oil flow and is also softening the solid structure of the seed material (Willems et al., 2008). For instance when pressing rapeseed (Bereens, 2007) reported that the temperature of the oil should not increase above 40 °C, because increasing temperature leads to higher phosphor content in the extruded oil and high phosphor content is an undesirable fuel property as it can cause deposits and clogging in engines. Oil point pressure is another important parameter and this is defined as the stage, which occurs just before oil flows out of compressed solid materials (Bereens, 2007). The material to be pressed consists of oil bearing solids and for the oil to be extruded from the solids it has to come to the surface of the seeds and to fill inter-particle voids (Sukumaran et al., 1989). The oil can leave the cell through the pores in the cell wall (Faborode et al., 1996). The oil point pressure is affected by the rate of deformation in mm/min that is screw speed in case of an expeller and the moisture content (Bereens, 2007).

In order to achieve maximum amount of oil by oilseed extraction methods involving the use of screw presses, this experiment was aimed at investigation of the influence of moisture content and the performance of screw press oil outlet chamber positions on the amount of oil extracted from *Jatropha curcas* L. seeds of different moisture content.

MATERIAL AND METHOD

Sample

Matured dried jatropha seeds of different collections obtained from Sumatra, Indonesia were used in this experiment. The seeds cleaned from unwanted materials such as dirt, broken seeds were in jute bags and stored in a warehouse facility at the Farmet Company in temperature range of 15–28 °C. Before the start of pressing, the moisture content of each batch of the jatropha seeds was determined to be 8.9 ± 0.6% (d.b.) and 11.1 ± 0.9% (d.b.) using the equipment Instalab 600, Dickey Jones Analyzer, USA. The seeds were further sorted by moisture content into two groups weighing 1000 ± 3 kg.

Screw press description

The pressing was carried out with a mechanical screw press type FL 200, the Farmet model, Czech Republic, Fig 1. The screw press was designed with 44 lamellas divided into 7 pressing positions as shown in Fig 2. The dimensions of the screw press include 2130 mm and 1280 m with and without engine, 560 mm in diameter, 1410 mm height and 930 kg weight. The screw press maximum capacity of material input was 180 kg/hr, which was powered by 16 kW electric motor and screw speed regulated directly between 25–40 min^{-1}. The screw press was also useful for pressing smaller vegetable oil seeds like rape, flax, sesame and sunflower.

Extraction process

The pressing process began by first heating the press for 15 minutes and then feeding with small amount of flax seeds. The heating helps to prevent the press from jamming during the pressing process. While the press machine was continuously heating, the jatropha seeds were then fed into the hopper and after that concurrently crushed and transported in the direction of a restriction by a rotating screw often called 'worm'. The continuous feeding of the jatropha seeds into the hopper caused pressure to increase to a level needed to overcome the nozzle. This pressure caused the oil to be removed from the solid material inside the screw press. Crude oil and press cake in a shape of small pellets were collected at the oil outlet and press cake exit, respectively. The pressing process of the *Jatropha curcas* seeds took one hour for each seeds moisture content group and repeated five times.

Fig. 1. Screw press lamellas at oil collection point

Mass flow of oil in each pressing chamber

Seven plastic beakers were placed at each chamber position for the collection of the oil during pressing. To obtain the mass flow of the oil in kg/hr, the formula below was used.

$$Q_f = M_{kg} \, . \, H_r^{-1} \qquad (1)$$

Where: Q_f (kg/hr) is mass flow of the oil, H_r (hr) is time for pressing (1 hour), M_{kg} (kg) is mass of the oil measured after the pressing process using the weight equipment KERN, DEK24K2N, UK.

Absolute mass flow of oil

This is the sum of individual mass flow of oil in pressing chamber and was calculated using equation (2), where Q (kg/hr) is absolute mass flow of oil, i (–) is position of pressing chamber and n (–) is number of pressing chambers .

$$Q = \sum_{i=1}^{i=n} Q_i \qquad (2)$$

Temperature of oil in each pressing chamber

Temperature was measured on the seven positions of the screw press at the oil collection point using a laser temperature device CEN-TECH 96451, USA. The temperature measurement was repeated every ten minutes.

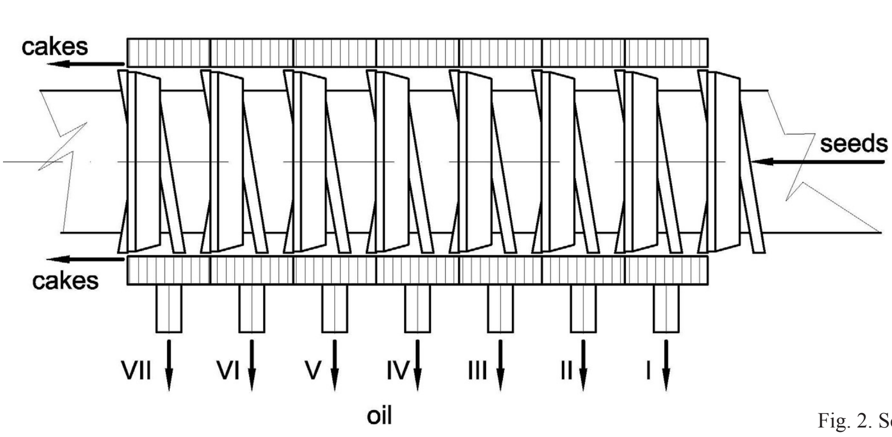

Fig. 2. Screw press schematic (I–VII; press positions)

Table 1. Measured values of mass flow of oil and temperature during the oil extraction process of *Jatropha curcas* L. seeds. Data in table are means ± SD

Chamber positions	Mass flow of oil (kg/hr)		Temperature (°C)	
	moisture content		moisture content	
	8.9% (d.b)	11.1% (d.b)	8.9% (d.b)	11.1% (d.b)
1	0.0 ± 0.0	0.0 ± 0.0	20 ± 0.8	23 ± 0.7
2	4.2 ± 0.4	3.8 ± 0.5	30 ± 0.9	32 ± 0.8
3	10.2 ± 0.2	9.5 ± 0.3	35 ± 0.5	37 ± 0.4
4	16.1 ± 0.3	14.9 ± 0.2	45 ± 0.5	48 ± 0.6
5	14.4 ± 0.3	12.8 ± 0.4	55 ± 0.6	58 ± 0.9
6	9.7 ± 0.5	9.1 ± 0.3	60 ± 0.9	62 ± 0.8
7	3.1 ± 0.3	2.8 ± 0.2	65 ± 0.8	68 ± 0.7
Sum	57.7 ± 0.8	52.9 ± 0.8	–	–

Table 2. Absolute mass flow of oil of jatropha seeds of different moisture contents. Data in table are means ± SD

Number of chamber positions	Absolute mass flow of oil (kg/hr)	
	8.9% (d.b.)	11.1% (d.b.)
1	0.0 ± 0.0	0.0 ± 0.0
1, 2	4.2 ± 0.4	3.8 ± 0.5
1, 2, 3	14.4 ± 0.6	13.3 ± 0.8
1, 2, 3, 4	30.5 ± 0.9	28.2 ± 1.0
1, 2, 3, 4, 5	44.9 ± 1.2	41 ± 1.4
1, 2, 3, 4, 5, 6	54.6 ± 1.7	50.1 ± 1.7
1, 2, 3, 4, 5, 6, 7	57.7 ± 0.8	52.9 ± 0.8

RESULTS AND DISCUSSION

Mass flow of oil from each pressing chamber

The results from the pressing experiments involving jatropha seeds of low and high moisture content, respectively are presented in Table 1 and Table 3. From the results it was clearly found that jatropha seeds of low moisture content produced the maximum amount of oil compared to jatropha seeds of high moisture content, which produced minimum amount of oil. This suggests that moisture content could be an important factor that can influence the oil output during oil extraction process. However, from both pressing, screw press positions 3, 4, 5 and 6 showed higher amounts of oil, while at screw press positions 2 and 7 lower amounts of oil were realized as shown in Fig. 3. At screw press position 1, there was no amount of oil. Comparatively, screw press position 4 had the highest amount of oil whiles screw press position 7 had the lowest amount of oil. It could be posible that at screw press positions 1 and 7, the pressing force required to cause the seeds to be crushed to exude the oil was low especially at screw press position 1 what suggests that energy was not efficiently utilized.

Absolute mass flow of oil

The absolute mass flow of oil was determined by equation (1) from the measured amounts of mass flow of oil (kg/hr) for different moisture contents of the jatropha seeds. The calculated amounts of the absolute mass flow of oil are shown in Table 2, and Table 3. These amounts are fitted by the second degree polynomial curves with very high coefficients of determination as shown in Fig. 3. Fig. 4 describes the growth theory principle. Comparing this theory with the results from the pressing with respect to absolute amount of oil, it was found out that jatropha seeds of low moisture content had the greatest amount of oil compared to seeds with high moisture content when the amount of oil from each screw press position was cumulated.

Table 3. Anova analysis of the measured parameters during jatropha oil extraction

Measured parameters	M.C.	F_{crit}	F_{ratio}	P	R^2
	(%) d.b.	(–)	(–)	(–)	(–)
Mass flow of oil	8.9	4.747	$1.986 . 10^{-6}$	0.9996	0.9923
	11.1	4.747	$1.317 . 10^{-6}$	0.9991	0.9911
Absolute mass flow	8.9	4.747	$0.646 . 10^{-3}$	0.9802	0.9999
	11.1	4.747	$0.206 . 10^{-3}$	0.9888	0.9998
Temperature	8.9	4.747	$2.346 . 10^{-6}$	0.9981	0.9877
	11.1	4.747	$1.874 . 10^{-6}$	0.9989	0.9866

It can be seen from the statistical analysis Anova for level of significance 0.05, that the values of F_{crit} were higher than F_{ratio} values for all measured parameters and amounts of P_{value} were higher than significance level 0.05. This shows that polynomial curves can be used for fitting measured parameters since relationships between measured amounts and fitted curve amounts were statistically significant. All values of F_{crit}, F_{ratio} and P_{value} are presented in Table 3. Also the coefficients of determination R^2 are in all experiments close to one and it shows that fitted curves described accurately measured amounts.

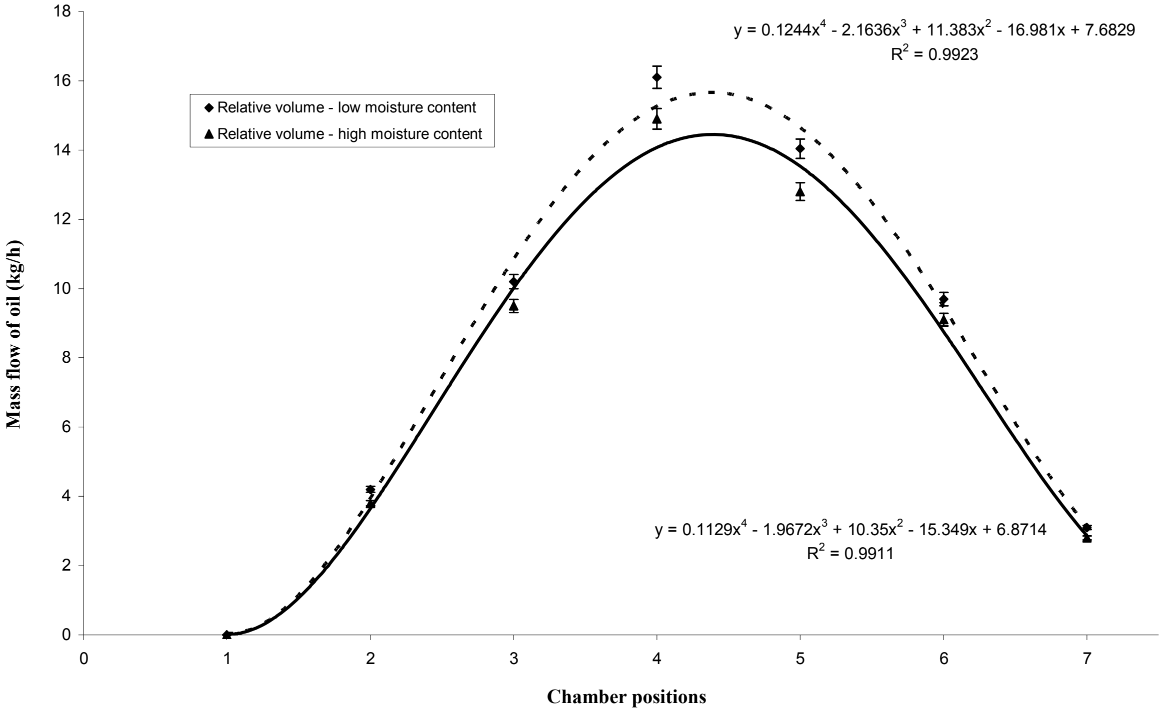

Fig. 3. Mass flow of jatropha oil (kg/hr) and the screw chamber positions

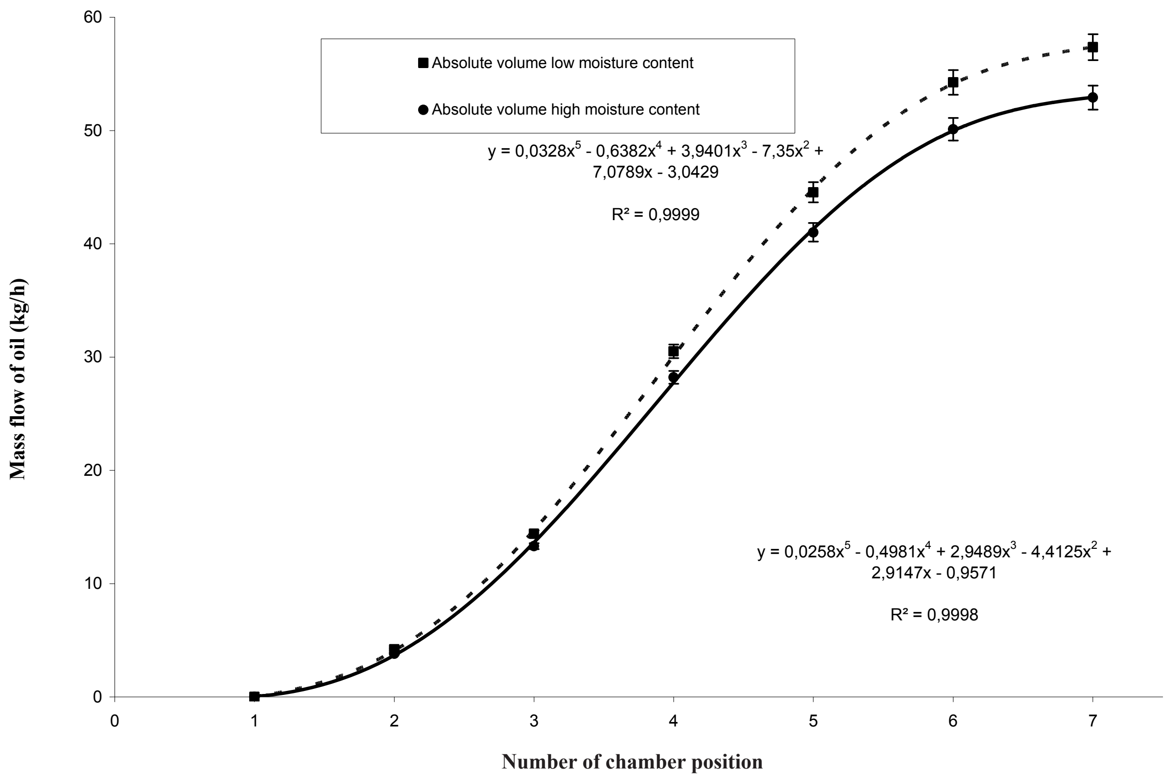

Fig. 4. Absolute mass flow of jatropha oil and the screw chamber positions

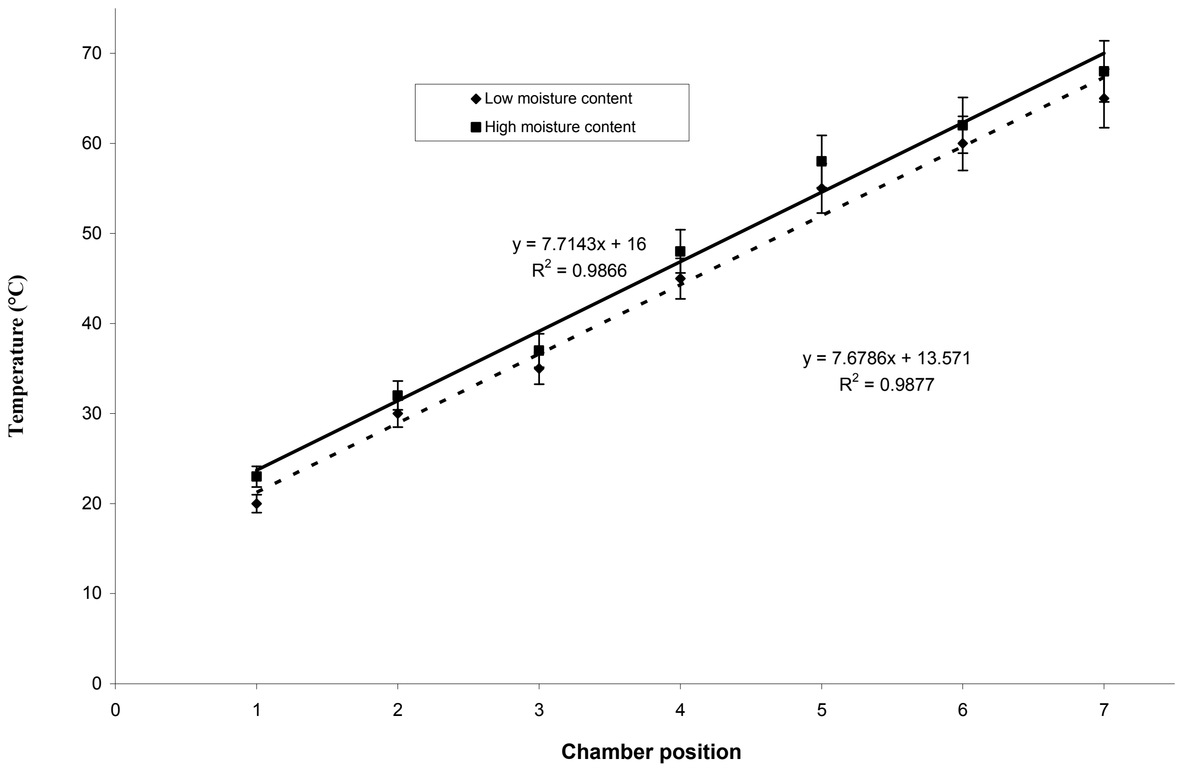

Fig. 5. Temperature and screw chamber positions during jatropha oil extraction

Screw press chamber positions and temperature dependency

With both experiments, the temperature showed increasing trend at all chamber positions. Fig. 5 shows the positive correlation R^2 coefficient of determination values of 0.9877 and 0.9866 for jatropha seeds with low and high moisture contents respectively. The temperature values ranged from 20 °C to 68 °C. However, screw press chamber position 7 recorded the highest temperature values of 65 °C and 68 °C, respectively. Also screw press chamber position 4 had the ideal temperature values of 45 °C and 48 °C. It was found that above or below this temperature range the amounts of oil obtained from the screw chamber positions were lower.

Mass flow of oil and moisture content dependency

It can be seen from Table 2, that the sum of mass flow of oil kg/hr from all chamber positions for jatropha seeds with low and high moisture contents was 57.7 kg/hr and 52.9 kg/hr, respectively. The difference of 4.8 kg/hr is an indication that jatropha seeds with moisture content lower than 8.9% (d.b.) or in the optimal range of 7% (d.b.) would increase the mass flow of oil kg/hr during pressing process.

CONCLUSION

It was found that the moisture content and the screw press oil outlet chamber positions are important factors that could influence the oil output during extraction. The result of the experiment showed that *Jatropha curcas* seeds of low moisture content produced maximum amount of oil compared to seeds with high moisture content. It is therefore necessary that moisture content of oilseed crops meet the optimum range prior to extraction in order to achieve the highest amount of the oil. The screw press equipment with respect to the oil outlet chamber positions should also be considered during the design process to enhance its efficiency. This is because minimum amount of oil was produced at some positions of the screw press oil outlet chamber.

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Výkonnost šroubového lisu při extrakci oleje ze semen *Jatropha curcas* L. při různých obsazích vlhkosti.

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Experiment byl zaměřen na stanovení výkonnosti šroubového lisu, typu FL 200 Farmet, při extrakci oleje ze semen *Jatropha curcas* L. při dvou různých obsazích vlhkosti semen – 8,9 % (db) a 11,1 % (db). Objem extrahovaného oleje ze semen *Jatropha curcas* byl měřen na sedmi různých pozicích lisu. Výsledky experimentu ukázaly, že na pozicích 3, 4, 5 a 6 bylo získáno maximální množství oleje a na pozicích 1, 2 a 7 minimální množství oleje. Výsledky také prokázaly, že ze semen s menším obsahem vlhkosti je možné získat více oleje než ze semen s vyšším obsahem vlhkosti. Měření teploty v jednotlivých pozicích šroubového lisu bylo také součástí tohoto experimentu. Závislost teploty a jednotlivých pozic lisu prokázala rostoucí trend v rozmezí 20 °C a 68 °C. Závěrem bylo zjištěno, že pro optimalizaci produkce oleje z *Jatropha curcas* L. semen s ohledem na nízkou spotřebu energie, ale také na požadavek vysoké účinnosti je nutné zohlednit vlhkost semen a konstrukci lisovacího zařízení.

šroubový lis; semena jatrophy; olej z jatrophy; obsah vlhkosti

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