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Comparison of oil press for jatropha oil – a review

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Abstract

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As petrol will soon be exhausted in the near future, Jatropha is going to be one of the substitute candidates for future biodiesel production. Countries of South-East Asia, such as Malaysia, they are going to start the establishment of Jatropha plantations assuming that Jatropha will be the main resource for biodiesel production. A press is commonly used to extract oils from Jatropha. An oil press can be manually driven or engine-powered. In this paper, we will review some available advances focused on mechanical extraction techniques, covering three types of press for Jatropha oil extraction. We have found that major points like operating principles, oil extraction levels, advantages and disadvantages of each press and important factors to increase oil recovery. Based on the study, three types of press are: ram press, which is ineffective; strainer press, which is able to produce more oil than others and cylinder-hole press, which is the best due to its capacity in extracting oil from Jatropha seeds for about 89.4% of oil yields.

Keywords: ram press; strainer press; cylinder-hole press

Several techniques have been successful in extracting oil seeds such as chemical (Ofori-boateng et al. 2012), mechanical (Henning, Bagani 2000), super critical (Louli et al. 2004), aqueous enzymatic (Jiang et al. 2010), ultrasound-assisted (Zhang et al. 2008) and three-phase partitioning (Shah et al. 2004) extraction methods. However, only two techniques are usually used to extract Jatropha oil. They are mechanical extraction and chemical extraction (Pradhan et al. 2010; Qian et al. 2010). Mechanical extraction is the most popularly used due to its easiness, economical and low maintenance. Despite of that, mechanical extraction needs further treatments, such as filtering and degumming. This technique can crush seeds or kernels or a mix of both. In comparison, for chemical extraction, only kernels are used as a material (Achten 2010). Especially for Jatropha oil extraction, types of oil press are ram press and two types of engine-driven screw press: strainer press and cylinder-hole press.

Jatropha is used as the object of study as it is expected to be the best energy source of oilseeds and their oil content is the highest among non-edible vegetable oilseed crops (Akintayo 2004; Achten et al. 2008). Fortunately, it can be planted throughout the world with conditions of tropical and subtropical land (Ceasar, Ignacimuthu 2011; Jingura 2011). Jatropha is a flowering hedge plant of the Euphorbia family, subfamily Platilobeae with more than 70 species of the genus. Among them

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it is *Jatropha curcas* (Jongschaap et al. 2007). *J. curcas* fruit is harvested when it is yellow-brown in colour (Fig. 1), which indicates that the seeds are mature enough and will give the best oil yields (Singh et al. 2008; Tambunan et al. 2012).

J. curcas seeds made up 25–35% of the oil content and it can be used as fuel or biodiesel (Makkar et al. 2011; Basili, Fontini 2012). It has a potential in the biodiesel manufacturing as the plant can be adapted to the wide agro-climatic conditions, easy propagation, drought endurance, rapid growth, low seed cost, short gestation period, richness in oil content and easy converting into biodiesel (Openshaw 2000; Divakara et al. 2010). Furthermore, two ways to make *J. curcas* oil into biodiesel are to make the engine adapt to the fuel or to make the fuel adapt to the engine (Pramanik 2003; Sahoo, Das 2009), but the oil must be first adapted to the international specifications and technical regulations of biodiesel; in the USA ASM 6751-02 and in the European Union EN 14214 (Mofijur et al. 2012). Another potential use of *J. curcas* oil is as a bio-jet fuel and it has been successfully used in turbine engines (Wardana 2010).

Many researchers have studied Jatropha oil with various analyses. Basili and Fontini (2012) described that *J. curcas* appears to be a serious candidate for energy alternative because the energy balance and the greenhouse gases are positive. Mofijur et al. (2012) recommended *J. curcas* as biodiesel. They found that *J. curcas* oil is the cheapest biodiesel feedstock. Koh and Ghazi (2011) presented that *J. curcas* seed has a high content of oil and it has similar properties to that of petroleum-based fuels. Rasmussen et al. (2012) found that carbon lost on the land can be repaired by replacing fossil fuels with Jatropha-based biodiesel. Kumar et al. (2012) studied sustainability issues for promotion of Jatropha biodiesel. They concluded that biodiesel from Jatropha oil promises to be a sustainable energy source.

In order to furnish more information about the Jatropha oil, this paper focused on studying the oil press in Jatropha oil extraction. Comparison of the performance of three types of oil press based on operating principles, oil extraction levels, advantages and disadvantages of their application and important factors to increase oil yields.

Comparison of oil press

The main principle of the mechanical extraction is crushing and pressing by using mechanical tools such as piston and screw expeller, even though in some traditional areas stone is still used. To see the differences among the individual presses, four important factors made the comparison.

Operating principles

Oil press can be used to separate *J. curcas* oil from the seed. Several types are available in the market from small to large scale of production. Each of the press has different characteristics and operation. Due to this, each of them is designed in accordance with the purposes. Presses can be found in different designs but similar operating principles.

Ram press. Karl Bielenberg had designed the first ram press (Bielenberg ram) (Fig. 2) in 1985. The technology was developed in Zimbabwe, Kenya, Mozambique and several other middle-southern African countries (Chachange 2003). Ram press was designed primarily for vegetable seeds with soft shells and small seeds like sesame, sunflower and shea nut (Ngongoni et al. 2007; Warra 2011).

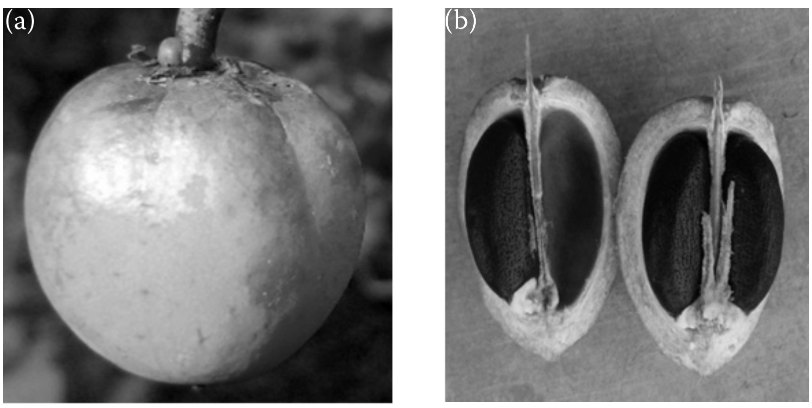

Fig. 1. *Jatropha curcas* fruit (a) and seed (b)

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Fig. 2. Ram press (Henning 2009)

Later, it was developed for seed crops with larger and harder seeds like Jatropha (Caniëls, Romijn 2010). Many models and specifications were later designed from this original machine such as CAPU ram, Camartec ram, approTEC ram, IAE ram and RAM-32 (Uziak, Loukanov 2007).

The ram press is operated manually by hand pressing. The seeds are pressed by a lever in the chamber using a ram piston. When the piston moves back, the seeds are automatically refilled at the end of the stroke. Then, when the lever is pushed, it moves forward to the pistons. Physical strength is needed to operate this press as it requires pressure 190 kg/cm^2 to extract oil from the seeds (Axtell et al. 2012). The press is mostly operated by one or more men. Therefore, the design has been improved to make it easier to press so that women can also operate this. However, the fuel is not used to operate it (zero fuel consumption).

Low skills are simply required for its operation with low cost for maintenance and repairing. Additionally, the piston's bearing is a spare part which is often broken due to its original material from plastic, but it can be replaced with a steel bearing to reduce repair costs (Sserunkuuma 1999). This press is portable and purchases can be made with funds jointly. Hence, this is suitable for domestic use in rural areas thus they are not too dependent on the delivery of raw materials from the city to produce soap, cosmetics, detergents, cooking, lighting and motive power (Tomomatsu, Swallow 2007).

Strainer press. The strainer press (Fig. 3) is powered by a diesel engine or an electric motor (Mpagalile et al. 2007). Steel bars are attached to a cage with gap sets for a discharge of the oil extraction and the gap can be adjusted in size to the type of the seed crop so that oil can be extracted from various types of seed crops, including palm fruit (Owolarafe et al. 2002; Eijck 2007). The seeds are fed into the hopper and then crushed, plus milled in the chamber. Further, the shaft of the screw is rotated forward manually to open the gap, thus oil flows through the oil outlet and the cake is pressed through the plates (Ferchau 2000). Fortunately, design can be made according to the needs that it can be equipped with a boiler and cooker. Many models were later designed from this original machine such as the Tinytech expeller, the Chinese expeller, the Sayari expeller, the Sundhara expeller (Henning 2009) and the Vyahumu expeller (Chachange 2003).

This press has a large construction, making it difficult to move but pressure force also generate large about the size of 40.8–357 kg/cm^2 (Beerens 2007) and this press is a suitable use for the industry due to the capability of extraction of 55 l/h (Henning 2008). However, a fuel consumption is used to drive the engine, which is about 10% of the oil produced (Brittaine, Lutaladio 2010).

Cylinder-hole press. The cylinder-hole press (Fig. 4) is driven by an electric motor. It has a screw rotating in a cylinder which is supported by bearings within the shaft. The shaft screw rotation can be adjusted by the engine rotation (Bates 2000). The seeds are fed into the hopper when a rotating screw crushes and transports them to the die. Further, the oil expressed is discharged through the oil output and the cake is discharged at the restriction (Oyinlola et al. 2004). Currently, 2 kinds have been developed from the original design, they are the Komet (Karaj, Müller 2011), and the Danish BT (Beerens 2007).

The cylinder-hole press is chosen due to its low cost of energy and the input power required 1–2.5% of the energy of the oil produced (FACT 2010). This press has potential to extract oil for all types

Fig. 3. Strainer press (Beerens 2007)

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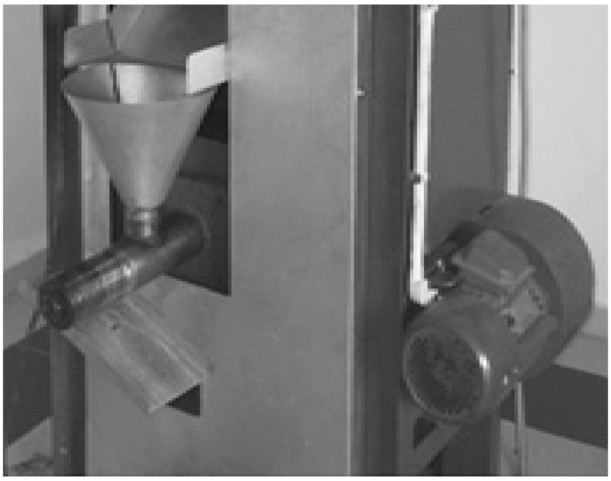

Fig. 4. Cylinder-hole press

of seeds varying from small to large production capacities and the construction is designed very simply so it can be easily moved but it to generate pressure force in a range 51–153 kg/cm^2. Oil can be produced from seed crops for up to approximately 200 kg/h (Singh et al. 2002). The cake is removed from the nozzle in the form of pellets, making it easy to place them in a bucket. Another advantage of this machine is that the work sites are clean, comfortable, quiet and the press is easy to use by the operator (Beerens 2007).

Another cylinder-hole press (Fig. 5) which successfully extracts oil from seed crops is a twin-screw extruder (Dufaure et al. 1999; Prat et al. 2002). The twin-screw extruder has two screws rotating in a cylinder with two parallel screw shafts that either rotate in the same direction (co-rotate) or rotate in opposite directions (counter-rotate). Further, co-rotation of the twin-screw extruder is the usually used method. It can extract oil from sunflower seeds giving a total oil yield of 78% but still has 10–13% oil

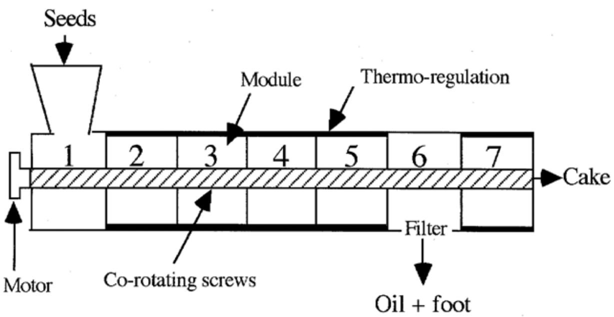

Fig. 5. Cylinder-hole press with a twin-screw extruder (Dufaure et al. 1999)

content in the cake, for Jatropha seeds obtained oil yield is 70.6% and 7.7% residual oil content (Evon et al. 2012, 2013). It is more effective due to higher transportation and better extraction at the twin-screw interface (Kartika 2005). The screw rotation is an important factor in achieving higher oil extraction using the twin-screw extruder as a result of the increased screw rotation speed causing a decrease in residence time (N'diaye, Rigal 2000; Sriti et al. 2012).

Oil extraction levels

Oil extraction levels or oil yield was calculated by comparing the oil content in the press cake to the initial oil content in the seeds extracted by using formulas (Beerens 2007):

$$Q_n = 1 - \left[\frac{\frac{Q_c}{(1-Q_c)}}{\frac{Q_s}{(1-Q_s)}} \right]$$

where :

Q_n – oil yield (%)

Q_c – oil content in press cake (g/100 g)

Q_s – oil content in seed g (g/100 g)

J. curcas has a high content ranging from 25 to 35% (Jingura 2011). It is calculated as 30 % mean of the oil content of Jatropha; then, if the oil yield is 75%, this means from 10 kg of Jatropha crushed, 2.25 kg oil (2.44 l with the density of 0.92 kg/l) is obtained (Forson et al. 2004; Beerens 2007).

Ram press. Various reports in the literature describe the Jatropha's oil yield using ram press (Table 1). Commonly, the capacity of a ram press is about 60–65% in 5–6 kg of seeds required to produce 1 l oil and the time required to process 8 kg of seed crops is 8 h (Tigere et al. 2006).

In this press, the important variable to increase oil yield is moisture content. The moisture content was determined as a percentage based on original fresh weight, seeds with low moisture content has a high oil yield. In rural areas, the seeds are usually dried under the sun to get low moisture content. Generally, the moisture content is about 5–15% d.b.

The ram press is not financially feasible due to its low capacity to extract oil from the seed, its clogging and its slow production (Benge 2006; Nielsen 2009). However, the ram press is still recommended

doi: 10.17221/22/2013-RAE

Table 1. Important variables to increase oil yield using ram press

Moisture content (% d.b)	Oil yield (%)	Reference
	62.5	Tewari (2007)
6–11	61	Raja et al. (2011)
6.2	60–65	Henning (2009)
12	62.5	Forson et al. (2004)
5–15	60	Axtell et al. (2012)
10	60	Openshaw (2000)
	62	Eijck (2007)
	62	Messemaker (2007)
	62	Brittaine, Lutaladio (2010)

for small-scale seed-oil production to reduce the purchase of oil and to improve the nutritional levels of the people by providing dietary fat as necessary after toxins dumped (Coker 2003; Henning 2004). It can be used by the press owner to produce oil for its own or as an extra income (Kamau, Nanua 2008).

The machine design is ineffective and must be developed from the original design. Some modifications could be considered to increase the performance of the machine, such as the redesign of the choke opening size, which is about 10.8–13.8 mm (Kamau, Some 2008) and piston (Henning, Bagani 2000).

Strainer press. Various reports in the literature describe the Jatropha's oil yield using strainer press (Table 2). The oil yield of 87% can be reached; 91% can be reached when cooked at a temperature of 70°C for 1 h after dual passing (Beerens 2007). Furthermore, the strainer press can extract 1 l of oil from 3–4 kg of seeds and the capacity of the machine can convert 2,000 kg of seed to oil in one hour (FACT 2006; Messemaker 2007), but the oil content in the cake is still found to be 10–12% (Singh et al. 2002). However, commercial oil extraction is undertaken with this machine due to its increased efficiency over the ram press.

In this press, the important variable to increase oil yield is moisture content, screw speed, gap size and cooking temperature. Especially for moisture content, it is required by approximately 2–16% d.b. Further, clearance distances between the screw and barrel (gap) set at 1.0–1.9 mm (Martínez et al. 2012; Sayasoonthorn et al. 2012). Component of press factors focused on the parts of the press that are designed to increase the pressure when extraction such as design of worm shaft (Singh, Bargale 2000; Aluko et al. 2002), its large capacity and high yields motorization (Bouffaron et al. 2012).

Table 2. Important variable to increase oil yield using strainer press

Cooking temperature (°C)	Moisture content (% d.b)	Screw speed (RPM)	Gap size (mm)	Oil yield (%)	Reference
70	2–4	55	1.8	87	Beerens (2007)
				80	Tewari (2007)
				87	Eijck (2007)
				77	Messemaker (2007)
				68	Henning (2009)
				70	Brittaine, Lutaladio (2010)
				68	Rabé (2005)
				75	Biswas et al. (2006)
110	9.69	120		73.14	Pradhan et al. (2011)
				70	
60–100	5–15	100		75	Axtell et al. (2012)
	15	50		75	Harmanto et al. (2009)
	6.2			75	Henning, Bagani (2000)

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Table 3. Important variable to increase oil yield using cylinder hole press-single screw extruder (cooking temperature 70°C)

Moisture content (% d.b)	Screw speed (RPM)	Nozzle size (mm)	Throughput (kg/h)	Oil yield (%)	Reference
2–4	49	9	13	79	Beerens (2007)
8.3	220	8	4	89.4	Karaj, Müller (2011)

Currently, the strainer press is used in industry but not for household use due to the high price and low profitability of the oil mill (Schmidt 2003). The cake removed through the gap is not in the form of pellets; making environment of the machine operation dirty and workers to be uncomfortable and unsafe. Another disadvantage of this machine is that it is not easy to use and it should be operated by trained operators (Henning 2008; Jongh, Nielsen 2011).

Cylinder-hole press. Various reports in literature describe the Jatropha's oil yield using Cylinder-hole press (Table 3). Max. oil recovery was reported to be 89.4% with a throughput of 4 kg/h using single screw extruder and 70.6% with throughput of 0.55 kg/h using twin screw extruder (Table 4).

In this press, the important variable to increase oil yield is moisture content, screw speed, nozzle size, cooking temperature, and throughput. Low throughputs often give rise to high oil recovery; the throughput should be at least 11 to 15 kg/h (Beerens 2007). Another important variable are temperature and energy requirements. The temperature of the barrel should be at 70.3 to 100°C and the energy requirement is 0.05 kWh/kg of feed for optimum pressure (Singh, Bargale 2000).

Advantages and disadvantages of presses

Each press has advantages and disadvantages, characteristics presses adapted to this purpose. The parameters used to compare the presses are operation of the press, spare part, construction, maintenance and repair, and oil recovery. Advantages and disadvantages of presses are showed in Table 5.

Table 4. Important variable to increase oil yield using cylinder hole press-twin screw extruder (Evon et al. 2013)

Moisture content (% d.b)	Screw speed (RPM)	Throughput (kg/h)	Oil yield (%)
5.49	153	0.55	70.6

Important processes to increase oil recovery

Oil recovery is obtained with a variety of important processes. Further, to simplify the processes rather than each press, to make it easier to recognize influence variables in each press, they are shown in Table 6.

Material preparation

Material preparation (Fig. 6) is an important process in increasing oil recovery. First step, Jatropha seeds must be harvested and washed to reduce impurities such as leaves, sands and stone entrance into the press. The impurities can damage the piston or screw expeller. Furthermore, the material is dried under the sun or using the oven so that the moisture content should be less than 8% (d.b.) (Zheng et al. 2003; Pradhan et al. 2010; Raja et al. 2011). High oil yield is produced from seeds with low moisture content. Another important process is cooking. Cooked seeds have an oil yield of 5–10% higher than the seeds uncooked (Pradhan et al. 2011). Usually, optimal oil recovery is obtained by cooking seed at 70°C. However, the cooking requires fuel and time to process; so many researchers ignore this process due to the results obtained when the deductible with the fuel used will be the same as if the process is not done.

Crushing

Crushing is a process to reduce the size of the seeds before pressing. The size of *J. curcas* seed is 1.7 ± 0.1 cm (width), 0.8 ± 0.1 cm (diameter) and 0.54 ± 0.09 g (weight) (Rodríguez-Acosta et al. 2010). This process is necessary to make particle size of *J. curcas* 2 mm (Lestari et al. 2011), thus while pressing both using a piston or screw expeller, max. pressure on the seed's capable piston is

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Table 5. Advantages and disadvantages of presses

Press	Parameter	Advantages	Disadvantages
Ram	operation	Hand operated, no needed stock of fuel and low skill is required (Axtell et al. 2012)	Easily clogged (Benge 2006; Jongh, Nielsen 2011)
	spare part	Stock of spare part is not needed (Sserunkuuma 1999)	Piston and bearing must be steel and it is expensive (Sserunkuuma 1999)
	construction	Simple and portable (Sserunkuuma 1999)	It is used for demonstration and individual not for industry (Tomomatsu, Swallow 2007; Kamau, Nanua 2008)
	maintenance and repair	Low cost, it can be manufactured by local workshop (FACT 2006)	Part made from local workshop is not strong (Uziak, Loukanov 2007)
	oil recovery	–	Lower oil recovery, the highest is 65 % and much oil in cake (Forson et al. 2004)
Strainer	operation	Engine driven. It can be used for all seed crops, including palm fruit (Owolarafe et al. 2002)	Operation by trained operators (Jongh, Nielsen 2011). High fuel consumption, fuel is used to drive the engine is about 10% of the oil produced (Brittaine, Lutaladio 2010)
	spare part	Many part is made of steel-like bar, cage, worm and barrel so that its strong and durable (Ferchau 2000)	Stock of spare part is required due to it cannot be manufactured by local workshop (Henning 2009)
	construction	The new design can be made according to the needs (Henning 2009)	Big press, it is hardly moved (Henning 2009)
	maintenance and repair	Continuous processing, it is not clogged (FACT 2006)	Repairs must be performed by a skilled mechanic (Eijck et al. 2010)
	oil recovery	High oil production, 55 l of Jatropha oil can be produced in 1 hour, so as to ensure the availability of raw materials derived from Jatropha oil (Henning 2008; FACT 2010). Oil yield is about 87% (Beerens 2007)	The oil content in the cake is still found to be 10–12% (Singh et al. 2002)
Cylinder-hole	operation	Electric motor driven, low energy consumption. The input power required is 1–2.5% of the energy of oil produced (FACT 2010). It can be used for individual, industry and research in laboratory (Beerens 2007)	Operation by trained operators (Jongh, Nielsen 2011)
	spare part	Low cost (FACT 2006)	Stock of spare part is required due to it cannot be manufactured by local workshop (Henning 2009)
	construction	Simple and portable (Karaj, Müller 2011)	–
	maintenance and repair	It is easy to clean (FACT 2006)	Repairs must be performed by a skilled mechanic (Eijck et al. 2010)
	oil recovery	Oil yield obtained is about 89.4% using single screw extruder (Karaj, Müller 2011) and 70.6 % using twin screw extruder (Evon et al. 2013)	–

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Table 6. Comparison of influence variable in presses

Press	Variable (unit)	Value	Reference
Ram	moisture content (% d.b.)	5–15	Raja et al. (2011)
	choke opening size (mm)	10.8–13.8	Kamau, Some (2008)
	oil yield (%)	60–62.5	Henning (2009)
	production capacity (kg/h)	5–6	Tigere et al. (2006)
	pressure (kg/cm^2)	190	Axtell et al. (2012)
Strainer	moisture content (% d.b.)	2–15	Pradhan, Naik et al. (2010)
	cooking seed temperature (°C)	70–100	Beerens (2007)
	gap size (mm)	1.0–1.9	Martínez et al. (2012)
	oil yield (%)	68–87	Beerens 2007; Rabé (2005)
	heat treatment at barrel (°C)	70–110	Beerens (2007)
	production capacity (kg/h)	15–2,000	FACT (2006)
	rotation speed (rpm)	50–12,040	FACT (2010)
	pressure (kg/cm^2)	8–357	Beerens (2007)
Cylinder hole-single screw extruder	moisture content (% d.b.)	2–8.3	Zheng et al. (2003)
	cooking seed temperature (°C)	70–100	Singh, Bargale (2000)
	restriction size (mm)	6–12	Beerens 2007; Karaj, Müller (2011)
	oil yield (%)	79–89.4	Beerens 2007; Karaj, Müller (2011)
	heat treatment at barrel (°C)	70–120	Beerens (2007)
	production capacity (kg/h)	up to 200	Singh et al. (2002)
	rotation speed (rpm)	49–355	Beerens 2007; Karaj, Müller (2011)
	pressure (kg/cm^2)	51–153	FACT (2010)
Cylinder hole-twin screw extruder	moisture content (% d.b.)	1.9–4.9	Evon et al. (2013)
	cooking seed temperature (°C)	70–100	
	restriction size (mm)	–	
	oil yield (%)	70.6	
	heat treatment at barrel (°C)	80–120	
	production capacity (kg/h)	up to 200	
	rotation speed (rpm)	153	

reached. Traditionally, seed can be crushed using stone (Chachange 2003) but the results are certainly not efficient. Nowadays, many presses were equipped with a crush machine (Henning 2009).

Extracting

Extracting process is required to separate the oil from Jatropha seeds. The machine design should estimate the size of the choke opening size, gap and restriction size for oil discharge. When the discharge is too large, the oil will be slight; if it is too small, the piston or screw expeller has to work harder. Especially in the ram press machine, it is difficult to move the piston back (Kamau, Some 2008). Fig. 7 shows the performance of each press to extract oil from Jatropha seeds.

The production of large quantities of oil is impossible using a ram press due to the high performance

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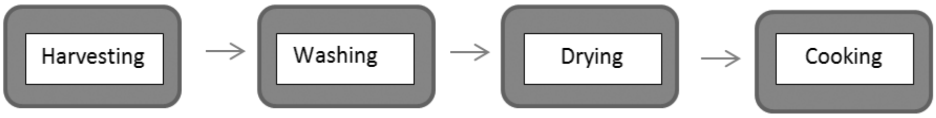

Fig. 6. Material preparation process

only 65% of oil yield and one hour is needed to produce one litre oil of Jatropha. Unfortunately, using an engine driven screw press, it is too expensive in rural areas. However, the ram press should remain in use as it helps rural people to produce oil as an energy source although it is inefficient (Jongh, Nielsen 2011). The design of the ram press can still be improved by creating a large piston, bearing and designing a choke opening that adjusts to the type of seed (Sserunkuuma 1999).

A strainer press is recommended for the use in rural areas as this machine is capable of extracting oil with a yield of 87% and the price is lower than that of a cylinder-hole press (Beerens 2007). It is powered by diesel engine and big press construction so that it can process up to 2,000 kg seeds/h (Singh et al. 2002). Another advantage of this machine is ability to work continuously. The press can also add additional tools such as crusher, boiler and cooker that can be adapted to the needs. Female operator can also operate this machine because high technology is not provided, but the operator must be trained first. However, oil yield of 87% requires a 10% fuel oil so that the net oil yield is 77%.

For cylinder hole for press, twin screw extruder produced too little oil – about 70.6%, while the cost to buy this press is high enough. Hence it needs further research to maximize effectivity of this press. The highest oil yield is extracted by using a cylinder hole press with single screw extruder. This machine is capable of working continuously, so throughput and the pressure are strong and stable. Oil extraction from the seed can be up to 89.4% from using this machine and net oil yield about 86.9% (Karaj, Müller 2011). Another advantage is that the operation of this machine is easy, portable, comfortable and safe for large scale oil production, especially oil for producing biodiesel fuel.

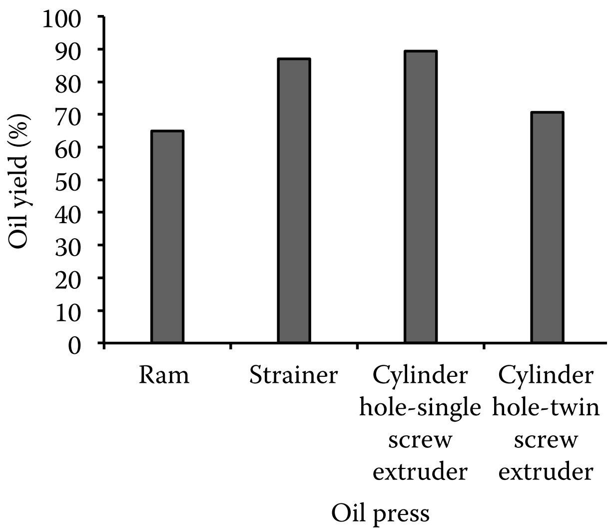

Fig. 7. The highest oil yield from each press

Future recommendation

J. curcas provides great opportunities for human as an alternative source of energy reducing fossil fuel. Research on presses must be further developed. Oil yield obtained should be close to 95% so that the production of fruits that is remaining can be maximized into a *J. curcas* oil recovery. Mechanical extraction is used more because the seeds are not separated from the kernel and the production costs are not large compared to chemical extraction. Pressure comes from the compression ratio. For the ram pressure of the piston, it gets the reaction force from the seeds while strainer and cylinder-hole exerted the friction force between the screw surface, seed and the inner cylinder. Consequently, the material used in areas of high pressure must be steel.

High oil yield is not only determined by a design of press, but also by the variables mentioned above. Therefore, press applications provide a good research

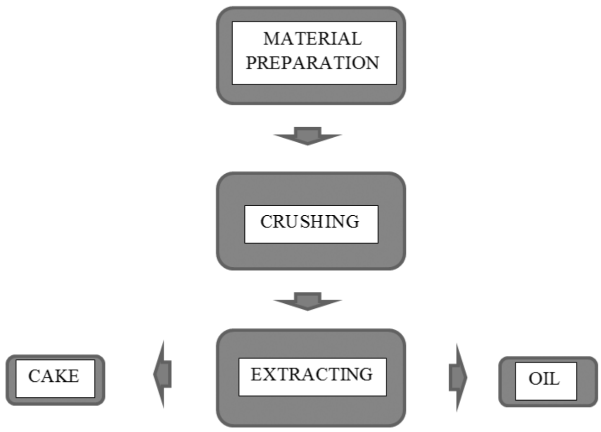

Fig. 8. Flow process to extract Jatropha oil

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opportunity. In future, research on mechanical extraction methods must follow the scheme below (Fig. 8).

CONCLUSION

The three types of press have different characteristics. Each has advantages and disadvantages. The ram press is the technology to produce oil in rural areas. These machines are ineffective but are still needed to produce oil in very small amounts. The strainer press can produce oil more effectively than a ram press, but still uses manual operation to open and close the gap. The cylinder press is the best machine due to its easy use and capability to extract oil from Jatropha seeds on a large scale with oil yields of about 89.4%.

Finally, the production of *J. curcas* oil as a raw material of biodiesel needs a machine that is able to work continuously with operators more focused on the process. Therefore, the cylinder-hole press and further research for its development are recommended.

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