Study on the pressing process of kemiri sunan’s oil (Reutealis trisperma) using screw-press machine at different feed material levels

S Nurjanah¹, JA Adshmiraj¹, MAM Kramadibrata¹, M Muhaemin¹, EMardawati², T Herwanto¹, Handarto¹, S Rosalinda¹, D Prijatna¹, M Saukat¹ and W Darajat³

¹Dept. Agriculture Engineering and Biosystem
²Dept. Food Technology – Faculty of Agro-Industrial Technology
³Dept. Pest and Diseases - Faculty of Agriculture
Universitas Padjadjaran, Bandung 40115, Indonesia

Email: sarifah@unpad.ac.id or sarifahnurjanah@gmail.com

Abstract. Kemiri Sunan (Reutealis trisperma) has great potential as a source of raw material for biodiesel production due to its high oil content. The oil is a non-edible oil that can be extracted using screw-press machine. In this study, a descriptive research with regression and correlation analysis was used to investigate the effect of feed material level on pressing performance and kemiri sunan’s oil quality. A variation of the feed material level (2, 4, 6, 8, and 10 kg) was fed into screw-press machine. The results showed that cylinder temperature and pressing time increased as the feed material level increased. The highest production (2.87 kg / hour) and yield (37.33%) capacity were obtained at 4 kg of the feed material level. Hence, increasing the feed material level did not affect the quality of the oil produced. Density, acid number, Free Fatty Acid (FFA), saponification number, kinematic viscosity and refractive index of oil produced ranged between 919.48-924.76 kg/m³, 30.82-47.79 mg KOH/g oil, 154.64-186.84 mg KOH/g oil, 15.59-56.34 mm²/s and 0.00328-0.00332 respectively.

1. Introduction
Biodiesel is an alternative energy source made from vegetable and animal oil. These fuels have more environmentally friendly properties, because biodiesel is biodegradable, non-toxic, produce better exhaust emissions, can burn perfectly, and high combustion efficiency [1, 2].

Biodiesel is defined as the mono-alkyl esters of vegetable and animal oils fatty acid. It is produced by transesterification process of triglycerides in the form of Fatty Acid Methyl Ester (FAME) or Fatty Acid Ethyl Ester (FAEE). Triglycerides are converted into FAME or FAEE and glyceride by alcohol and a strong base catalyst [1, 3, 4].

Some vegetable oils that are usually used as the feedstock of biodiesel are palm oils, soybean, sunflower, rapeseed, and jatropha [4, 5, 6, 7]. However, kemiri sunan (Reutealis trisperma) also has high potential as a biodiesel feedstock [8, 9]. Carlos et al. [9] found that kemiri sunan has an oil content of 62%, with the seed productivity of 12 tons / ha / year. Another advantage of kemiri sunan as a raw
material for biodiesel is that the seeds are toxic so that these oils do not compete with food products. The toxin contained in kemiri sunan is \( \alpha \)-eleostearic acid compound [10].

Generally, kemiri sunan oils were extracted using pressing machine [8, 9]. One of the pressing machines that usually used is screw pressing machine. This machine has several advantages: the production capacity becomes greater because the pressing process can be carried out continuously, saving production time because it does not require preliminary treatment (size reduction and cooking / heating of seeds), and the yield produced is higher.

This study aimed to investigate the effect of feed material level on pressing performance and kemiri sunan’s oil quality (density, acid number, Free Fatty Acid, saponification number, kinematic viscosity and refractive index). A variation of the feed material level (2, 4, 6, 8, and 10 kg) was fed into screw-press machine

2. Methodology
2.1. Material and Instrument
Sample of kemiri sunan was obtained from Garut Regency, West Java, while chemicals used include phenolphthalein, KOH, 95% ethanol, and HCl. Instrument used in this study include crack machine, screw-press machine, oven, ostwald viscometer, water-bath, burette, pycnometer, and ABBE refractometer.

2.2. Method
The method used in this research is descriptive method with correlation-regression analysis. This research was conducted with five levels of treatment, namely the amount of 2 kg, 4 kg, 6 kg, 8 kg and 10 kg. Each treatment was repeated 3 times. The parameters observed were raw material analysis (proximate analysis), extraction process conditions (material temperature, extraction time and production capacity), and analysis of kemiri sunan oil quality (SNI 7431-2015: moisture content, density, acid number and FFA/Free Fatty Acid, saponification numbers, kinematic viscosity, and refractive index).

2.3. Preparation
Some processes were applied before extraction of the oil: sortation, drying and kernel separation. Sortation was conducted to separate undesirable material such as small, young and small seed. Kemiri sunan was dried under sunlight until the water content is less than 7%, then the shell and kernel were separated using crack machine (1 HP, 0.75 kW, RPM; 920 r / minute). Second sortation was carried out to separate the undesirable kernel: white (not yellow), hard (not soft), moldy kernels.

2.4. Pressing process
Screw-press machine was applied with the condition of 5 HP, 3.7 kW, RPM 1455 r / minute. During the pressing process, pressing time and the temperature distribution on the material were measured. Kernels were feed into the machine manually. Oil and cake (residue) were separated automatically. In order to maximize the yield cake were re-feed for 3 times.

3. Results and Discussion
3.1. Analysis of kemiri sunan seed
Moisture and lipid content of kemiri sunan seed used in this research was investigated using proximate analysis. The proximate analysis of the kemiri sunan is presented in Table 1. The moisture content of the kemiri sunan after drying is 3.48% wb. This moisture content level allows a good breakdown of the kemiri sunan shell, because the maximum of moisture content requirement for cracking and pressing process is 7% [11]. In addition to moisture content, the lipid content needs to be known to see the effectiveness of the pressing process by comparing the extracted oil with the lipid content in the material. The value of the lipid content of the kemiri sunan is 53.47%. This value is higher than lipid content of kemiri sunan reported by Berry [12]. This may due to the kemiri sunan used in this research was older than [12]. According to Tillman el al [13], the difference in lipid content depends on plant age, the older the plant, the more lipid production.
### Table 1. Composition of kemiri sunan seed

| Composition    | Percentage (%) | Reference [12] |
|----------------|----------------|----------------|
| Moisture content | 3.48           | 10.23          |
| Ash            | 4.07           | 3.3            |
| Protein        | 8.97           | 17.06          |
| Lipid          | 53.47          | 51.34          |
| Carbohydrates  | 30.01          | 18.07          |

#### 3.2. Pressing Temperature

Temperature was evaluated to find out the temperature differences among the feed levels. Temperature measurements are carried out on three points, at the beginning, middle and end of the screw-pressing machine cylinder. Figure 1 shows the relationship between input level and cylinder temperature. The greater the amount of feed levels, the higher the temperature of the cylinder. This is due to the friction among the materials and between the material and the cylinder. The friction generate mechanical forces which causes the temperature to rise. The increase in temperature is directly proportional to the increase in feed levels with the equation of \( y = 3.852x + 29.138 \) \( (R^2=0.9965) \).

![Figure 1. Cylinder temperature at different feed levels](image.png)

The cylinder temperature is between 30-50°C. This result is smaller than the previous research conducted by Sudrajat [14] with the temperature of 50-60°C. Pressing at high temperatures has a higher efficiency but will produce oil with poor quality due to the possibility of oil being degraded or damaged. While pressing at low temperatures has lower efficiency but can produce oil with good quality because the risk of oil degradation is smaller [15].

#### 3.3. Pressing time

Pressing process of the kemiri sunan kernel took time between 9.15-124.38 minutes, with the fastest pressing time is 2 kg (9.15 minutes) and the longest pressing time is 10 kg (124.38 minutes). As the amount of feed level increases, the length of time it takes longer (figure 2). Increasing feed level exponentially increase the time of pressing process with the equation of \( y = 3.9644e^{0.6588x} \) \( R^2 = 0.978 \).
3.4. Yield of kemiri sunan oil
The yield of kemiri sunan oil produced in this study ranged between 32-37.33% with an average oil yield of 34.63%. That value is lower than [8] and [12], moreover it does not meet the standards set by the Ministry Agriculture (Kementerian Pertanian) [16] (38.10-42.00%). This may cause by several factors, including the pressing machine factor and feed factor.

Table 2. Yield of kemiri sunan oil

| Feed (kg) | Yield (%) | Standard deviation |
|-----------|-----------|--------------------|
| 2         | 32.00     | 0.25               |
| 4         | 37.33     | 0.19               |
| 6         | 35.69     | 0.69               |
| 8         | 34.15     | 0.47               |
| 10        | 33.98     | 0.15               |

The low yield value may cause by the pressing machine performance. The machine did not worked optimally due to overuse without good periodic maintenance of the engine. As a result the pressing machine decreased in performance which resulted in the oil produced not meeting the standards. In addition, the varieties of kemiri sunan seeds can influence the oil yield too. Varieties used in this research is Kemiri Sunan-1, where this variety has a smaller yield than other varieties. Kemiri Sunan-2 or Kermindo can achieve a yield value of 50%, it is different from the Kemiri Sunan-1 variety which has a value between 38-42%.

3.5. Quality of kemiri sunan oil
The quality of the kemiri sunan oil presented in Table 3. The results showed that the differences in feed levels did not affect the quality of kemiri sunan oil for its moisture content, density, acid value, free fatty acids, saponification number, kinematic viscosity, as well as refractive index.
Table 3. Quality of kemiri sunan oil

| Parameters                              | Feed (kg) |
|-----------------------------------------|-----------|
|                                         | 2         | 4         | 6         | 8         | 10        |
| Moisture content (%)                    | 0.106     | 0.313     | 0.079     | 0.348     | 0.163     |
| Density (kg.m³)                         | 919.484   | 922.987   | 920.726   | 924.762   | 918.660   |
| Acid value (mg KOH/g material)          | 33.777    | 30.824    | 32.227    | 47.793    | 46.593    |
| Free Fatty Acid (%)                     | 16.715    | 15.254    | 15.948    | 23.651    | 23.058    |
| Saponification Number (mg KOH/g material) | 181.607   | 186.722   | 186.846   | 160.659   | 154.642   |
| Kinematic Viscosity (mm²/s)             | 48.243    | 45.598    | 56.338    | 52.020    | 53.698    |
| Refractive index                         | 0.003     | 0.003     | 0.003     | 0.003     | 0.003     |

4. Conclusion
In conclusion, cylinder temperature and pressing time increased as the feed material level increased with the formula of \( y = 3.852x + 29.138 \) and \( y = 3.9644e^{0.6588x} \), respectively. However, increasing the feed material level did not affect the quality of the kemiri sunan oil. Density, acid number, Free Fatty Acid (FFA), saponification number, kinematic viscosity and refractive index of oil produced ranged between 919.48-924.76 kg/m³, 30.82-47.79 mg KOH/g oil, 15.25-23.65%, 154.64-186.84 mg KOH/g oil, 45.59-56.34 mm²/s and 0.00328-0.00332 respectively.

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