

## Design and manufacture a coconut milk squeezer

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**Abstract.** The process of cooking oil production generally is started by grating the ripe coconut meat, then pressing the grated meat to obtain coconut milk, and finally heating the coconut milk to obtain the cooking oil. Pressing mechanism to obtain coconut milk is a very important step and decisive in the process of producing cooking oil. The amount of milk produced depends on the pressure applied at the time of pressing grated coconut. The higher the pressure, the more milk is obtained. Some commercial mechanical pressing tools that available in the market are not efficient due to the working steps too much and take long time per cycle of work. The aims of this study was to design and manufacture a power screw squeezer for the collection of coconut milk. Power screw produces a compressive force in the cylinder to push and press the grated coconut until the end of the cylinder while the coconut milk and coconut dregs flow out simultaneously. Screw press was designed using straight shaft configuration with square profile. Performance test was done to investigate the actual capacity and yield of milk produced. The results showed that squeezer of grated coconut worked well with capacity an average of 13,63 kg/h and coconut milk yield of 58%.

### 1. Introduction

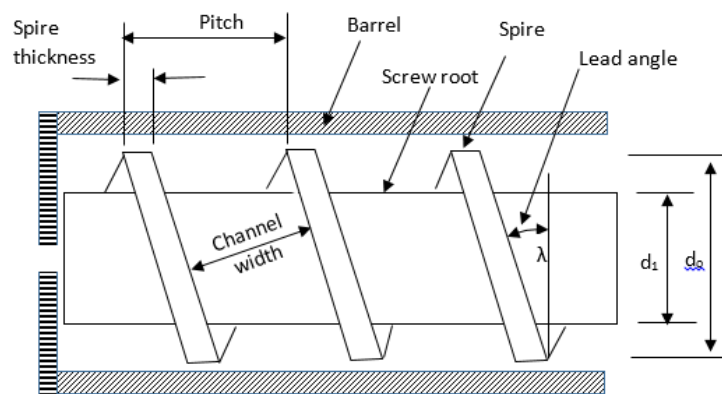
Cooking oil included in the group of nine basic commodities that generally is needed by Indonesian community, therefore cooking oil must be available and be sold freely in the market every day. The production of cooking oil from coconut as raw materials, in addition to the main results in the form of coconut milk and cooking oil, also produced a byproduct in the form of coconut dregs or the solid part which is a valuable source of protein for livestock feeds. The cooking oil production process from coconut generally starting from grated the mature coconut meat, then pressing the grated meat to obtain coconut milk, and finally heating the coconut milk to obtain the cooking oil. Currently coconut grater tool has equipped an engine that driven by electrical power. While squeezing process is still done manually by hand using filters that made from the part of coconut tree or cloth. The local practice of squeezing the grated coconut is still done traditionally, because the equipment is simple, it is also cost-effective and does not require any particular skill [1], [2]. Although in the market has also been available a mechanical squeezer of screw-piston, and screw-hydraulic, but such tool is not efficient due to many steps that must be done in one working cycle. The working mechanism of this tool is very long and difficult for the operator, besides that working posture and dimension of the tools are not ergonomics, cause fatigue and musculoskeletal disorders [3] – [5]. The aims of this research were to design and manufacture a mechanical tool for squeezing grated coconut using a power screw mechanism to produce coconut milk continuously. Power screw unit is a tool that is very commonly used for oil extraction, because the working steps are very simple, continuous, and easy to operate. The main data taken into consideration for prototype design are: the variable auger rotational speed, the variable pressure in the barrel, the



diameter of barrel, and the diameter of the auger shaft [6]. Generally, the rotational speed of a power screw for pressing process ranges between 15 - 40 rpm [6] – [9]. The next variable is the working pressure inside the barrel. Reference [10] shows the final pressure in a squeezing process of jatropha oil plants (jatropha seeds) minimum 4 MPa. Because the grated coconut is not a grain, but very soft material then the pressure is much lower. In this study assumed working pressure of 2 MPa.

## 2. Experimental Method

Power screw configuration with a straight shaft is the most common mechanism used for press tools, because the manufacturing process is easy. The distance of the pitch and diameter of the screw base is constant as depicted in Fig. 1.



**Figure 1.** Geometry of power screw with straight shaft.

Press volume flow rate can be evaluated by using the relation as in [6]:

$$Q_v = V_{te} (1 - \varepsilon) n k 60 \text{ (m}^3/\text{h)} \quad (1)$$

where:

$V_{te}$  - is the theoretical volume of the material displaced by the auger spire during a complete rotation, in the exhaust area ( $\text{m}^3$ )

$n$  - auger rotation speed (rpm)

$k$  - coefficient taking into account the material flowing back through the spire extremities, as well as the incomplete feed with material ( $k = 0,2 - 0,35$ )

$\varepsilon$  - pressure ratio, calculated using equation  $\varepsilon = (v_i - v_f)/v_i$ , with  $v_i$  = initial volume of the material ( $\text{m}^3$ ), and  $v_f$  = final volume ( $\text{m}^3$ ).

The theoretical volume of the material displaced by the auger spire is calculated using the following equation:

$$V_{te} = \frac{\pi}{4} (d_2^2 - d_1^2) (p - \delta) \text{ (m}^3\text{)} \quad (2)$$

where:

$p$  - the auger spire pitch (m)

$\delta$  - thickness of the auger spire (m)

$d_2$  - outer diameter of the auger spire (m)

$d_1$  - inner diameter of the auger spire (m)

By replacing in equation (1) the expression of the theoretical volume given by equation (2), it results the expression of the press volume flow rate:

$$Q_v = \frac{\pi}{4} (d_2^2 - d_1^2) (p - \delta) (1 - \varepsilon) n k 60 \text{ (m}^3/\text{h)} \quad (3)$$

The yield of coconut milk is calculated by using the equation:

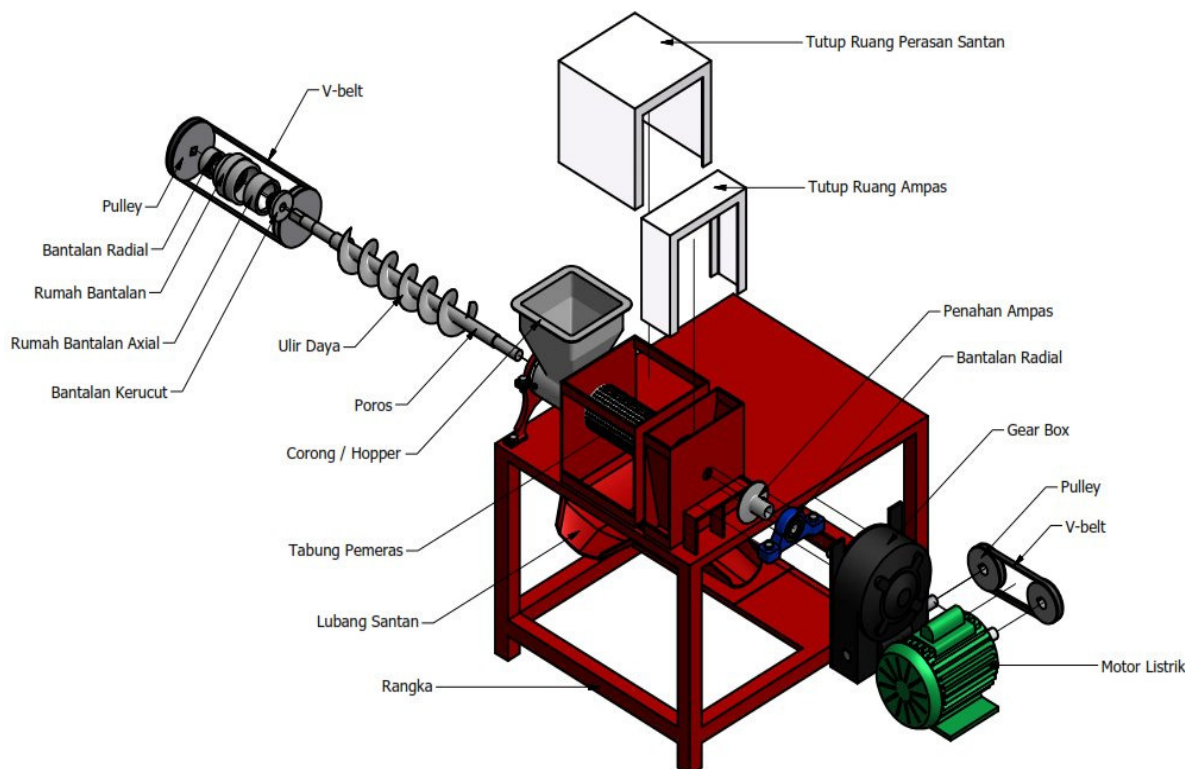
$$\text{Milk yield} = \frac{w_o - w_f}{w_o} \times 100\% \quad (4)$$

where:

$w_o$  - initial weight of grated coconut (kg)

$w_f$  - final weight of grated coconut (kg)

In this study, rotation of the screw shaft was designed for 15 - 30 rpm which rotated by electric motor. Working pressure assumed 2 Mpa. Furthermore selected barrel diameter  $d_o = 72$  mm, the outer diameter of the screw  $d_2 = 71$  mm, and a screw shaft diameter  $d_1 = 22$  mm. Power screw length  $L = 300$  mm, pitch distance  $p = 42.8$  mm, and thread thickness  $\delta = 1.2$  mm. Grated coconut is smooth and slick material, therefore the friction coefficient between grated coconut and surface of the barrel is smaller. The coefficient of friction  $\mu = 0.2$ , pressure ratio  $\varepsilon = 0.5$ , backflow coefficient  $k = 0.35$ , and based on the experiment volume of 1 m<sup>3</sup> grated coconut equal with weight 352 kg [11]. Illustration prototype design of power screw for squeezing grated coconut and their components are shown in Fig. 2.



**Figure 2.** Design of power screw squeezer.

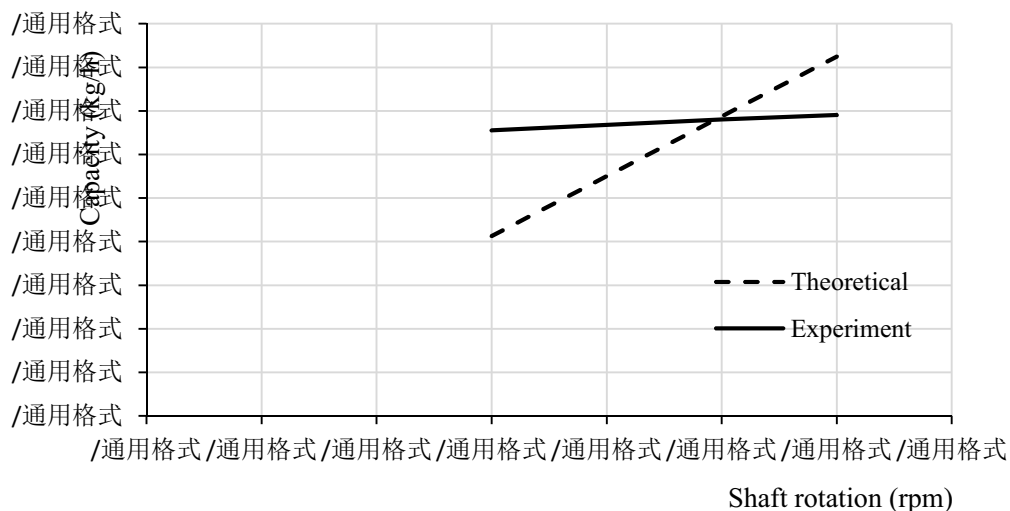
### 3. Results and Discussion

A complete assembly of grated coconut squeezer has been tested with variables of screw shaft rotation varied from 15, 25, and 30 rpm. Performance test included actual production capacity and yield of milk produced. The theoretical capacity was calculated refer to (3), and milk yield refer to (4). The results of the tests were presented in Table I.

**Table 1.** Performance test results.

Parameter	Unit	Analysis of result			Mean
		1	2	3	
Shaft rotation	rpm	15	25	30	23.33
Grated coconut weight	kg	1.00	1.00	1.00	1.00
Dregs weight	kg	0.41	0.42	0.42	0.42
Time for pressing	min	4.58	4.40	4.43	4.44
Milk yield	%	59.00	58.00	58.00	58.33
Actual capacity (experiment)	kg/h	13.10	13.63	13.85	13.52
Theoretical capacity	kg/h	8.25	13.75	16.50	12.83

The experiment results in Table I shown that the average capacity of the squeezer about 13.52 kg/h. This result was very satisfactory because the experimental results were in the range of theoretical calculations. The optimum condition occurred at rotation of 25 rpm, where the theoretical capacity equal to the experimental capacity about 13,63 kg/h, as shown in Fig. 3.

**Figure 3.** Capacity of the squeezer.

Based on the analysis in Table I, the milk yield was obtained an average of 58%. This result was higher when compared to hand squeezing which the milk yield about 52.9% [12]. Likewise, when compared to use a mechanical piston screw the milk yield about 51.25% [13].

#### 4. Conclusion

The power screw squeezer for pressing grated coconut run successfully as designed. The performance of this pressing unit was better than screw piston type. The actual capacity about 13,63kg/h, and the milk yield produced an average of 58%. This squeezer can be used and suitable to support small industries in the process of making traditional cooking oils.

#### Acknowledgment

Authors are highly thankful to Udayana University for providing financial support to carry out the research work, under the scheme of Research Group grant (*Skim Penelitian Grup Riset*).

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