Rice Bran Oil Extraction by Screw Press Method: Optimum Operating Settings, Oil Extraction Level and Press Cake Appearance

Supakit SAYASOONTHORN, Sudsaisin KAEWRUENG, Pannatorn PATHARASATHAPORNKUL

Abstract: The appearance of rice bran ‘cake’ or discharge from a screw press corresponds to the level of oil produced in the extraction process. The relationships between operating settings, oil extraction level and cake appearance were studied. Cake characteristics reliably indicate the expected oil recovery extraction level. These conclusions applied to both Chainat 1 rice bran and parboiled rice bran. Variables were the speed of the screw press (set at five levels from 8.5 to 19.8 r/min) and corresponding clearance distances between the screw and barrel (set between 1.0 and 1.9 cm). Results showed that the maximum levels of extraction were 4.17% for the rice bran and 8.20% for the parboiled rice bran. At the maximum extraction level, the apparatus continuously discharged cake that were hard, crispy, flaky, shiny and polished on one side but dull and coarse on the other.

Key words: rice bran; screw press; press cake

The milling of rice bran, the cuticle between the paddy husk and grain, produces either rice bran (RB) or parboiled rice bran (PB), depending on whether the grain is milled raw or had previously been soaked in hot water, steam-treated and dried. Rice bran is a rich source of oil, protein, fiber and life-essential nutrients (Heinemann et al, 2005; Amarasinghe et al, 2009). Bran accounts for 5%–8% of the weight of brown rice milled (Houston, 1972; Sarmento et al, 2006). The oil content of parboiled rice bran varies from 22% to 28% depending on the paddy variety (Sivala et al, 1991). The two most common methods for separating oils from raw materials are extraction and pressing (Proctor and Bowen, 1996). Mechanical pressing is the most popular method worldwide for separating oil from vegetable oilsseeds (Mrema and McNulty, 1985; Singh and Bargale, 2000) using either of two pressing methods, hydraulic or screw. The mechanical screw press, used for the extraction of oil from oilsseeds (Omobuwajo et al, 1999), also called an expeller, is popular because of its simple and sturdy design. It is moreover easily maintained, operable by semi-skilled workers. It adapts quickly for processing different oilsseeds and utilizes a continuous expulsion process.

Even though solvent extraction is more efficient than the mechanical press (Amarasinghe and Gangodavilage, 2004; Ghosh, 2007), the latter is favored for its simplicity and safety (Singh and Bargale, 2000). Nonetheless, it displays a significant shortcoming: relative inefficiency, leaving 8%–14% of the available oil in the cake (Srikantha, 1980). Prior investigations of this shortcoming have not produced any conclusive results. Previous studies focused on the press design (Singh and Bargale, 2000; Oyinlola et al, 2004) and the absence in visual inspection of the rice bran press cake to identify the optimum degree of extraction.

This study therefore aims to investigate the press cake characteristics of rice bran oil expression for on-farm or community enterprise in the hope of improving income and employment in rural areas.

MATERIALS AND METHODS

This study utilized RB and PB from long-grain rice (Chainat 1) milled in Nonthaburi Province, Thailand. Rice bran with an initial 6% moisture content was selected and the initial oil was evaluated.

A screw press manufactured in Thailand was used in the tests as shown in Fig. 1. Its main components are: (a) driving motor (1 hp, 220 V); (b) maddock screw type; (c) barrel (longitudinal barrel with 16 bar cage inside upon which the screw rotates); (d) feed hopper with adjustable speed feed motor; (e) power transmission and gear reduction unit; and (f) frame. The screw press acts by the effect of its rotation within the stationary cylindrical barrel. As the screw rotates towards the discharge end of the barrel, the bran is conveyed under pressure along and to the end of the barrel. The extracted oil drains through perforations in the barrel’s bottom while the pressed rice cake is discharged through the circular aperture between the tapered end of the screw and the barrel.

The two most important parameters for oil extraction in this type of machine are the screw speed and the compression clearance as measured by the scale fixed on the shaft as shown on Fig. 2. For this study, the screw press was configured to run at speeds of 8.5, 11.3, 14.1, 16.9 and 19.8 r/min by adjusting the pulley diameter at 3, 4, 5, 6 and 7 inches and at the compression clearance of 1.0, 1.3, 1.5, 1.7 and 1.9 cm. Adjustment was performed using the wedge mounted on the screw shaft, with the compression clearance at 1.0 cm being the tightest position.

The rice bran was evaluated for oil extractability via the Soxhlet extraction method. The pressed crude oil was stored for 48 h at room temperature and filtered using only gravity
membrane separation without any additional pressure. The filtered oil was then centrifuged (Beckman Coulter, model Allegra X-12R) at 10,000 r/min for 30 min to separate the residue at the bottom. Oil recovery rate was calculated with the following equation:

\[
\text{Oil recovery rate (\%) = } \frac{W_{\text{Rice bran oil}}}{W_{\text{Rice bran}}} \times 100;
\]

Where \(W_{\text{Rice bran oil}}\) is the weight of the rice bran oil (g) and \(W_{\text{Rice bran}}\) is the weight of the rice bran (g).

**RESULTS AND DISCUSSION**

The average initial oil content of the RB and PB were 18.47% and 21.85%, respectively. Tables 1 and 2 summarize the extraction results of raw rice bran oil (RBO) and parboiled rice bran oil (PBO) under the tested conditions. A maximum RBO oil extraction rate of 4.17% was achieved at 1.7 cm clearance and 8.5 r/min, while 8.20% was achieved at 1.3 cm clearance and 8.5 r/min for PBO. More oil was obtained from the PB than from RB under identical conditions, because during parboiling, the fat and water-soluble nutrients migrated from the rice kernel to the bran (Subrahmanyan et al, 1938; Raghavenor Rao et al, 1965; Anuradha et al, 1980).

The press could not extract oil at 1.0, 1.3 and 1.5 cm clearances and 8.5 r/min rotation speed due to clogging of the press cake inside the bar cage and screw (Fig. 3-A and B). Screw speed was also observed to affect the oil extraction level. For both bran types, oil recovery rate increased when screw speed was decreased to 8.5 r/min from 19.8 r/min. A screw speed of 8.5 r/min was thus found optimal for oil extraction. Results showed that the effect of the clearance between the screw and the barrel was significant at 95% of the confidence level, likely because of the time and the screw’s compressing the rice bran. The more tightly the clearance is set, the more slowly the rice bran press cake moves through the exit aperture. The longer the rice bran remains under compression, the more oil is delivered. However, at 1 cm clearance, the screw was too tight and the oil recovered was reduced as a result of the cake’s clogging between the bar cage (Fig. 3-A) and the screw (Fig. 3-B). Conversely, a greater clearance between the screw and barrel led to lesser oil recovery presumably due to the rice bran’s short exposure to compression. The low screw speed (8.5 r/min) showed the highest oil recovery rate for a particular clearance, presumably because its force was applied during a longer extraction time.

Fig. 4 showed press cake for the corresponding oil recovery rate categories as fully described in Table 3. The rice bran press

### Table 1. Yield of rice bran oil (RBO) at various extraction conditions.

<table>
<thead>
<tr>
<th>Screw press speed (r/min)</th>
<th>Clearance (cm)</th>
<th>Oil recovery rate (%)</th>
<th>Average</th>
<th>DMRT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>8.5</td>
<td>-</td>
<td>-</td>
<td>4.17</td>
<td>3.71</td>
</tr>
<tr>
<td>11.3</td>
<td>2.44</td>
<td>3.02</td>
<td>2.65</td>
<td>1.30</td>
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<tr>
<td>14.1</td>
<td>1.60</td>
<td>1.80</td>
<td>1.35</td>
<td>1.09</td>
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<tr>
<td>16.9</td>
<td>1.00</td>
<td>1.32</td>
<td>0.93</td>
<td>0.82</td>
</tr>
<tr>
<td>19.8</td>
<td>0.78</td>
<td>0.93</td>
<td>0.87</td>
<td>0.49</td>
</tr>
<tr>
<td>Average</td>
<td>1.16</td>
<td>1.41</td>
<td>1.16</td>
<td>1.57</td>
</tr>
<tr>
<td>DMRT</td>
<td>a</td>
<td>c</td>
<td>a</td>
<td>d</td>
</tr>
</tbody>
</table>

The means in rows and columns followed by different letters are significantly different at 5% level of probability.

### Table 2. Yield of parboiled rice bran oil (PBO) at various extraction conditions.

<table>
<thead>
<tr>
<th>Screw press speed (r/min)</th>
<th>Clearance (cm)</th>
<th>Oil recovery rate (%)</th>
<th>Average</th>
<th>DMRT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>8.5</td>
<td>6.00</td>
<td>8.20</td>
<td>7.30</td>
<td>4.50</td>
</tr>
<tr>
<td>11.3</td>
<td>5.00</td>
<td>7.10</td>
<td>6.20</td>
<td>4.20</td>
</tr>
<tr>
<td>14.1</td>
<td>5.00</td>
<td>6.60</td>
<td>6.10</td>
<td>3.84</td>
</tr>
<tr>
<td>16.9</td>
<td>4.80</td>
<td>6.50</td>
<td>6.10</td>
<td>3.30</td>
</tr>
<tr>
<td>19.8</td>
<td>3.78</td>
<td>6.50</td>
<td>6.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Average</td>
<td>4.92</td>
<td>6.98</td>
<td>6.34</td>
<td>3.77</td>
</tr>
<tr>
<td>DMRT</td>
<td>c</td>
<td>e</td>
<td>d</td>
<td>b</td>
</tr>
</tbody>
</table>

The means in rows and columns followed by different letters are significantly different at 5% level of probability.
cake characteristics listed in Table 3 can be used as a reliable indicator of the oil extraction level. The screw press user can certainly identify the maximum extraction point with reasonable accuracy because the rice bran press cake properties are fairly constant. In general, as the oil extraction level increases toward its maximum, the rice bran press cake becomes characterized by its texture and discharge pattern. These results agree with the findings of a previous study (Sivakumaran and Goodrum, 1988). Thus, a user of this screw press technology can estimate the level of oil extraction efficiency from a visual inspection of the output bran cake. In practice, therefore, they should observe the rice cake output and adjust the operating settings to achieve the desired level of oil extraction.

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**REFERENCES**
