THE EVALUATION OF WALNUT OIL EXTRACTION PARAMETERS

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Abstract: Walnut is known because of its high polyunsaturated fatty acids content, they reduce blood pressure, total and LDL cholesterol. In the walnut oil production, it is very important to find appropriate parameters to pressing the oil from seeds. In this study, walnut oil was obtained by pressing by screw press UNO FM 3F by Farmet Company, Czech Republic. The effects of pressing frequency of 30, 50, 70, and 90 rpm and nozzle size of 6, 8, 10 mm in pressing experiments were monitored. The walnuts oil density was 876.3 kg/m³ and seed oil content was determined by extraction ranges 70.17% in dry basis. The results have confirmed that when the screw rotation speed is changed from 30 to 90 rpm, the press capacity increases on average from 0.71 to 2.05 kg/h but simultaneously the oil yield reduces from 41 to 12%. Finally, the optimal pressing parameters were determined to 30 rpm and nozzle size of 6 mm.

Key Words: walnuts seeds, walnuts seeds oil, screw press, rotation speed, efficiency

INTRODUCTION
Walnut kernels have a high oil content which varies from 52 to 72% (Poggetti et al. 2017, Labuckas et al. 2014, Martínez et al. 2006, Zwarts et al. 1999). Walnut is well known because of its high polyunsaturated fatty acids (PUFA) content (Mehmet 2009, Crews et al. 2005). Regular consuming of walnuts reduces the risk of diabetes (Kendall et al. 20 11), has a positive effect on brain function (Hou et al. 2014) and reduces the amount of cholesterol in the blood (Kodad et al. 2016, Uzunova et al. 2015, Avanzato 2010, Park et al. 2008).

Oil from walnut kernel can be obtained in three ways, mechanical extraction (pressed oil), chemical or solvent extraction and supercritical CO₂ extraction (Singh and Bargale 2000). The extraction by mechanical screw presses is typical for lower proportion of collected oil. Screw pressing has been studied for a large variety of oilseeds (linseed, canola, crambe, chi seeds and others) (Ezeh et al. 2016, Ling et al. 2016, Wang et al. 2016, Mridula et al. 2015, Savoire et al. 2013).

But benefits of screw pressing are to produce high-quality oil containing bioactive compounds, without using organic solvent. Screw pressed method have low investment costs for equipment compared with supercritical fluid extraction method. Benefits of screw pressing is providing a simple and reliable method of processing small batches of seed. The amount and quality of pressed walnut oil are critical for efficiency of commercial production (Jokic et al. 2016, Labuckas et al. 2014, Teh and Birch 2013, Martinez et al. 2008, Turkmen et al. 2006, Koski et al. 2002).

Considering the increasing demand of new sources of high quality vegetable proteins, this study evaluates the effect of different oil extraction parameters conducted by screw pressing.

MATERIAL AND METHODS
Walnut kernels
Walnut kernels were vacuum-packed and purchased in the supermarket chain originated in Czech Republic. Seeds were selected a mixed together. They were ground in a stainless-steel mill
with pro-homogenization sample to the fraction of size from 0 mm to 6 mm. Then, the material was pressed.

**Screw press parameters**

The screw press type UNO FM 3F made by the Farmet Company in Czech Republic was used for experimental measurements. This model is suitable for pressing all kinds of oilseeds. The drive is configured for three-phase voltage with variable speed of the main drive using a frequency converter, which enables better optimization of pressing parameters. The press components are: an electric motor (1.5 kW power), transmission, pressing device, motor starter and frequency converter (this allows precise adjustment of rpm). The screw rotation speed was adjusted on 30, 50, 70 and 90 rpm. The pressing device components are: a matrix, 220 mm screw, head, heating mantle, nozzle holder and nozzles of different in diameter (from 6 mm up to 10 mm).

**Determination of water content of walnut kernels and density of walnuts oil**

Water content of walnut kernels was determined by dehydration at 103 °C (in a drying oven type FN 120, Nuve, made in Ankara, Turkey) according to the CSN EN ISO 665 (461025) Oilseeds - Determination of moisture and volatile matter content. Analysis was made on 5 g of grinded sample, weighted with an accuracy of 0.1 mg. Results are expressed as the ratio of water loss per gram of dried sample. Density of oil was determined pycnometrically according to the CSN EN ISO 6883. This international standard specifies a method for the determination of the conventional mass per volume (“litre weight in air”) of vegetable fats and oils. Determination of water content and density was performed in triplicate.

**Determination of the total fat content in the seeds and cakes through extraction**

To determine the total fat content, we used the Soxhlet extractor with hexane as a solvent. Crushing the walnut kernels always took place immediately prior to the oil extraction and from the pressed cakes directly after the pressing. For this purpose, the IKA MF 10 basic on the sieve with the average of 3 mm was used. Emphasis was always placed on precise cleaning of the grinder in order to avoid distorting the results. The temperature of the extraction mixture was kept by the heating mantle closely around the boiling point of hexane (70 °C). Extraction was always carried out for 8 hours. Subsequently, the hexane was evaporated on the vacuum evaporator, type IKA RV 10 control at the pressure of 200 kilopascals until the hexane was evaporated. After that, the pressure was lowered down to 60 kilopascals for another 2 hours at the constant temperature of 40 °C. The weight of total fat was then measured on the scales type KERN EG 2200-2NM.

**Statistical analysis**

Analytical determinations were done in triplicate and data were reported as means ± standard deviation. Analysis of variance (ANOVA) and Tukey’s honestly significant difference (HSD) tests were conducted to determine the differences among which means that the statistical significance was declared at p ≤ 0.05. These statistical evaluation methods were applied using the computer software package “Statistica 12.0” (StatSoft Inc., USA).

**RESULTS AND DISCUSSION**

The input raw material had the following values of the main parameters. The water content was at 2.95 ± 0.21%, which corresponds to the values conventionally recommended and recommended for storage (Wco 2017, Poggetti et al. 2017, Christopoulos and Tsantili 2015). The total fat content was set at 70.17 ± 0.455%, which is rather higher in comparison with other authors (Poggetti et al. 2017, Labuckas et al. 2014, Martínez et al. 2006, Zwarts et al. 1999). The walnut oil density was 876.3 ± 5.3 kg/m$^3$. Özcan, (2009) indicates value 972.1 kg/m$^3$ and Gharibzahedi et al. (2014), in different cultivars, from 921.2 to 921.8 kg/m$^3$. Demirbas (2008) indicates significantly different value, which is 912.0 kg/m$^3$.

The pressing of walnut kernels was carried out at speed 30, 50, 70, and 90 rpm and nozzles 6, 8 and 10 mm were used. These two parameters significantly affected the press capacity. This means that one kilogram of kernels may produce 0.41 to 0.12 kg (41–12%) of crude oil (see Table 1). The results
match with the results of Gharibzahedi et al. 2013 who indicates the highest yield crude pressed oil 34.9% and Labuckas et al. (2014) who states oil extraction in between 41.0–44.4%.

The results (Table 1 and Figure 1) indicate that at higher speeds of the pressing and higher mean of nozzle, the oil yield drops. Specifically, speed change affects extraction up to 57% and nozzle change up to 53%. This effect could be attributed to the conveying capacity of the press that increases with screw rotation speed and increased mean of nozzle (Vadke and Sosulski 1988, Pouštka et al. 2010, Savoire et al. 2013).

Table 1 shows clearly, that the amount of oil in pressed cakes depends on the extraction parameters from 0.03 up to 0.52 kg (3–52%). The higher values are caused by inappropriate combination of the rotational speed of press and nozzle, which would not be seen in the commercial use. Labuckas et al. (2014) states, that in the pressed cakes there is leftover in between 27.7–31.1% of oil and Jokić et al. (2014) states, that the value of residual oil in press cakes was in the range from 7.95 to 17.57% depending on applied pressing parameters. This oil can be obtained from the following extraction. Moreover, the amount of sediment was found in the range between 0.1–0.35 kg (10–35%).

<table>
<thead>
<tr>
<th>Mean of nozzle (mm)</th>
<th>Speed (rpm)</th>
<th>Time of pressing 1 kg kernels (h)</th>
<th>Yield of oil from 1 kg kernels (kg)</th>
<th>Press capacity (kg/h)</th>
<th>The weight of pressed cakes (kg)</th>
<th>The amount of oil in pressed cakes (kg)</th>
<th>The weight of sediment (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>0.37 ± 0.0043a</td>
<td>0.28 ± 0.0042b</td>
<td>0.76</td>
<td>0.46</td>
<td>0.18</td>
<td>0.24</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>0.27 ± 0.0017a</td>
<td>0.24 ± 0.0018f</td>
<td>0.89</td>
<td>0.56</td>
<td>0.31</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>70</td>
<td>0.18 ± 0.0010b</td>
<td>0.16 ± 0.0016a</td>
<td>0.89</td>
<td>0.70</td>
<td>0.46</td>
<td>0.14</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
<td>0.17 ± 0.0025a</td>
<td>0.12 ± 0.0014d</td>
<td>0.71</td>
<td>0.78</td>
<td>0.52</td>
<td>0.10</td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>0.33 ± 0.0104d</td>
<td>0.27 ± 0.0053b</td>
<td>0.82</td>
<td>0.50</td>
<td>0.26</td>
<td>0.23</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>0.27 ± 0.0042a</td>
<td>0.31 ± 0.0053b</td>
<td>1.15</td>
<td>0.42</td>
<td>0.19</td>
<td>0.26</td>
</tr>
<tr>
<td>8</td>
<td>70</td>
<td>0.20 ± 0.0017c</td>
<td>0.20 ± 0.0037d</td>
<td>1.00</td>
<td>0.62</td>
<td>0.37</td>
<td>0.18</td>
</tr>
<tr>
<td>8</td>
<td>90</td>
<td>0.17 ± 0.0025a</td>
<td>0.15 ± 0.0016a</td>
<td>0.88</td>
<td>0.71</td>
<td>0.42</td>
<td>0.13</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>0.20 ± 0.0029c</td>
<td>0.41 ± 0.0040d</td>
<td>2.05</td>
<td>0.29</td>
<td>0.03</td>
<td>0.35</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>0.19 ± 0.0025b</td>
<td>0.38 ± 0.0085f</td>
<td>2.00</td>
<td>0.30</td>
<td>0.04</td>
<td>0.33</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>0.22 ± 0.0025c</td>
<td>0.33 ± 0.0060b</td>
<td>1.50</td>
<td>0.36</td>
<td>0.11</td>
<td>0.29</td>
</tr>
<tr>
<td>6</td>
<td>90</td>
<td>0.00 ± 0.0000e</td>
<td>0.00 ± 0.0000e</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Legend: Values are means ± standard deviations of triplicate determinations. Means followed by different lowercase letters in the same column indicates significant differences (P < 0.05) between treatments involving pressing.
The sediment is made by the imperfect separation of the oil from the pressed cakes. It usually appears in small quantities and can be separated by settling the oil and filtering it. The higher amount of this sediment is again caused by an inappropriate combination of press parameters and should be avoided in regular operation.

*Figure 1 Effect of the number of revolutions and mean of nozzle of the press on the yield of oil (kg)*

The oil yield depends on the pressing speed, attained pressure, the length of pressure action, conditions of outflow of oil at a maximum pressure, viscosity, and oil temperature (Black and Bewley 2000). During this study, it was found out that the combination of 6 mm nozzle and the speed of 90 rpm made the extracting not possible as the press was becoming blocked.

*Figure 2 Effect of the number of revolutions and mean of nozzle of the time of pressing (h)*
CONCLUSION

The benefit of screw pressing is to provide a simple and reliable method of processing small batches of seed. From the results of this study, it is followed that the optimal combination of press parameters uses 6 mm nozzle and 30 rpm. It is thus possible to achieve the highest moulding of more than 400 g of oil per kilogram of walnuts kernels, which means that a press capacity is 2.05 kg/h. In this setting, only about 3% of the oil remains in the pressed cakes. Part of this oil can still be obtained during the post-process. The measured results can be used in commercial practice for optimizing the pressing process for pressing of oil from walnuts kernels.

ACKNOWLEDGEMENTS

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