Agronomy Research **16**(S1), 1118–1123, 2018
https://doi.org/10.15159/AR.18.059

Extraction of oil from rapeseed using duo screw press

Č. Mizera[1,*], D. Herák[1], P. Hrabě[2] and A. Kabutey[1]

[1]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Mechanical Engineering, Kamýcká 129, CZ165 21 Praha 6 Suchdol, Czech Republic
[2]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Material Science and Manufacturing Technology, Kamýcká 129, CZ165 21 Praha 6 Suchdol, Czech Republic
[*]Correspondence: mizera@tf.czu.cz

Abstract. This study was focused on the analysis of optimize the pressing process of rapeseeds (*Brassica napus L.)* using screw press. For pressing of oil a screw press Farmer 20 – duo (Farmer 20, Farmet a.s., Ceska Skalice, Czech republic) was used. The screw rotation speed 10, 20, 30, 40, 55 and 65 rpm was used. Oil recovery efficiency and specific mechanical energy were decreased when the seed material troughput was increased. It has been found that the optimal operation point for screw press Farmer 20 – duo was at 20 kg h^{-1} rapeseed throughput. The specific mechanical energy at the optimal operation point was 0.61 kWh kg_{oil}^{-1} Maximum oil recovery efficiency 82.6% was found at the lowest screw speed.

Key words: Farmer 20, oil recovery efficiency, pressing energy.

INTRODUCTION

Plant oil production plays an important role not only in the food industry. Mechanical pressing of oil seeds results in significantly lower oil yield compared to solvent extraction. However, health and environmental concerns related to the use of hazardous solvents as well as economic considerations regarding energy consumption and waste production have led to a revival of interest in mechanical pressing (Uitterhaegen & Evon, 2017). The original technology of pressing oil seeds was using a hydraulic press. This technology is characterized by the high efficiency of oil extraction, but it is non-continuous operation. That is why the oil extraction technology has been used for many years. In recent years, more and more scientific work has focused on extracting oil (Crowe et al., 2001; Zheng et al., 2003; Evon et al., 2013; Uitterhaegen & Evon, 2017). This process is ensured by means of a co-rotation twin screw press (Evon et al., 2013; Uitterhaegen & Evon, 2017) or screw press with a single screw of variable pitch and channel depth (Crowe et al., 2001; Zheng et al., 2003). Pressing the sunflower and coriander oils with a co-rotation twin screw press were investigated by Evon et al. (2009) and Uitterhaegen et al. (2015). In the second case, screw is slowly rotated in a cage type barrel and this ensures continuous operation (Isobe et al., 1992). Movement of the material through a press depends mainly on friction between the material and the barrel's inner surface and screw surface during screw rotation (Evon et al., 2013). In practice, some parameters have been investigated that influence the pressing process. It was found that the moisture content of seeds affects performance screw press (Singh & Bargale, 1990; Singh et al., 2002). Lower seed moisture causes better oil yield, but also increases pressing temperature. Higher oil temperatures promote oxidation and degrade oil. Pressing rapeseeds dealt with a number of authors (Herak et al., 2015; Kabutey et al., 2017). Pressing of rapeseeds using the duo screw press (Farmer 20, Farmet a.s., Ceska Skalice, Czech republic) represents a very interesting option for small and medium – sized farmers. Regarding the optimization of oil extraction on the Farmer 20 screw press, other studies did not influence the different settings of the screw press. Therefore, the aim of this study was to analyze and optimize the pressing process at different screw rotation speed for rapeseeds pressing, focusing on optimizing the pressing process of the press Farmer 20.

MATERIALS AND METHODS

Sample

Rapeseeds (*Brassica napus L.*) obtained from the Ceska Skalice, Czech Republic were used for this experiment. The moisture content $M_c = 8.4 \pm 1.4\%$ (w.b.) of sample was determined using the standard oven method, ASAE method (ASAE S410.1 DEC97, ASAE, 1998). The procedure was that the initial mass of the sample before and after oven drying was weighed. For measuring of mass of each sample m_s *(g)* an electronic balance (Kern 440–35, Kern & Sohn GmbH, Balingen, Germany) was used. The test was repeated three times and result averaged.

Mechanical screw press Farmer 20 - DUO

The experiments were carried out on mechanical screw press Farmer 20 – duo (Farmer 20, Farmet a.s., Ceska Skalice, Czech republic). The duo screw press is powered by a 4.0 kW electric motor. Maximal capacity specified by the manufacturer in terms of seed throughput is 20 kg h^{-1}. The press is equipped with two screw head units (therefore the designation 'duo'). Each unit is equipped with a press cylinder with mesh size 1 mm. Nozzle diameter and screw speed were varied as the processing parameters. For measuring of parameters such as, rotation speed, torque, pressure, temperatures, mass of oil and mass of cake the different sensors were installed. Oil was collected into plastic containers. The schema screw press is shown in the Fig. 1.

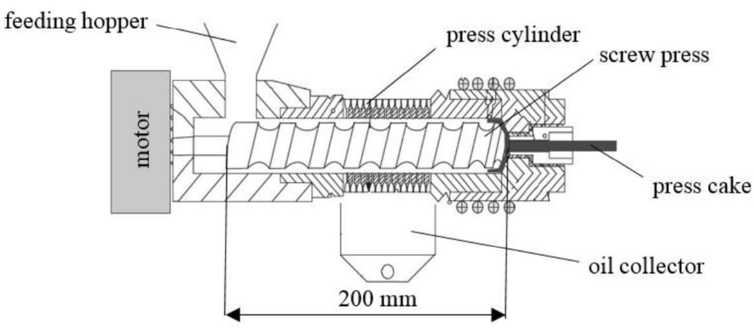

Figure 1. Scheme of mechanical screw press for oil extraction (Karaj & Müller, 2011).

Oil recovery efficiency was determined as the mass of pressed oil expressed as a percentage of the oil inside seeds. The oil content of the seeds was determined using the Soxhlet apparatus.

Processing of measured data

The measured values of pressing process were analysed with computer program Mathcad 14 (MathCAD 14, PTC Software, Needham, MA, USA), (Pritchard, 1998) uses Levenberg-Marquardt algorithm for data fitting (Marquardt 1963). The determined models of curves were statisticaly verified by using ANOVA.

RESULTS AND DISCUSSION

Fig. 2 shows the effect of screw rotation speed on electric power input of duo press and pressing time for 10 kg of rapeseeds. The graph shows 5 curves for different screw rotation speed in the range 10–65 rpm. Fig. 2 shows that, as expected, pressing time (for 10 kg rapeseeds) and power input decrease significantly as the screw rotation speed increases. This is due to a decrease in torque with increasing screw rotation. Higher speed means higher mechanical shear. This leads to self-heating of the material (*i.e.* higher material temperature) and thus to a lowering in material viscosity and in machine torque. (Karaj & Müller, 2011).

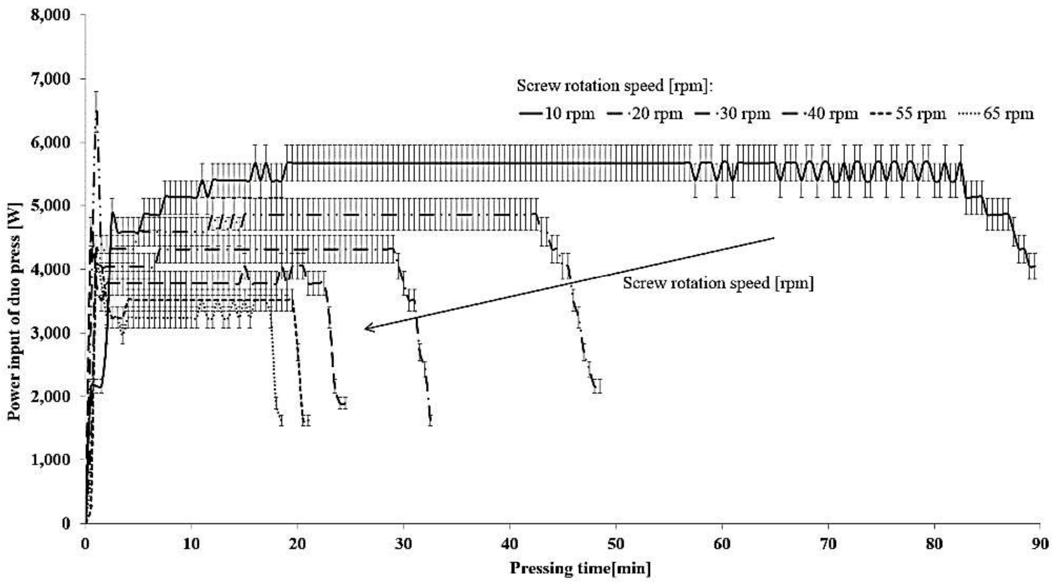

Figure 2. Effect of screw rotation speed on electric power input of duo press and pressing time for 10 kg of rapeseeds.

Fig. 3 shows the correlation of specific energy input and oil recovery efficiency versus material throughput. It is evident that specific energy (Es_{seed}) decreases as the troughput (TP) increases. The same dependence is also visible for specific energy for oil (Es_{oil}).

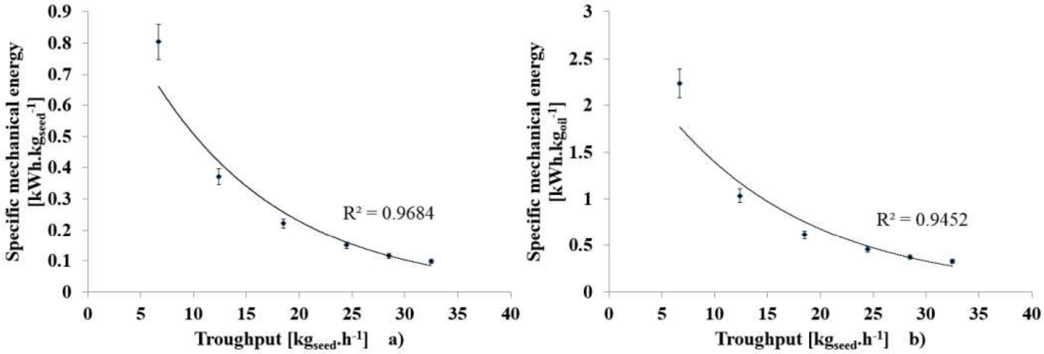

Figure 3. Dependence between seed material troughput and mechanical energy for a) pressing one kilogram of rapeseeds; b) obtaining one kilogram of oil.

The measured values of energy, depending on the troughput, decreases according to the exponential function and can be described using the Eq. 1 and Eq. 2

$$Es_{seed} = 1.1263 \, . \, e^{-0,08 \, . \, TP} \tag{1}$$

$$Es_{oil} = 2.8649 \, . \, e^{-0,072 \, . \, TP} \tag{2}$$

The model can be used only for the given troughput (5–35 kg h^{-1}) and mechanical screw press (Farmer 20). At an optimum troughput value 25 kg h^{-1}, the specific mechanical energy is about 0.5 kWh kg_{oil}^{-1}. Similar values were also found in linear pressing of bulk rapeseeds (Kabutey et al., 2017). Oil temperature 55 °C and press cake temperature 43 °C were measured at a troughput of 25 kg h^{-1}.

Fig. 4 shows the dependence between oil recovery efficiency (η_{oil}) and troughput (TP). Higher oil gain was achieved at lower troughput up to 20 kg h^{-1}.

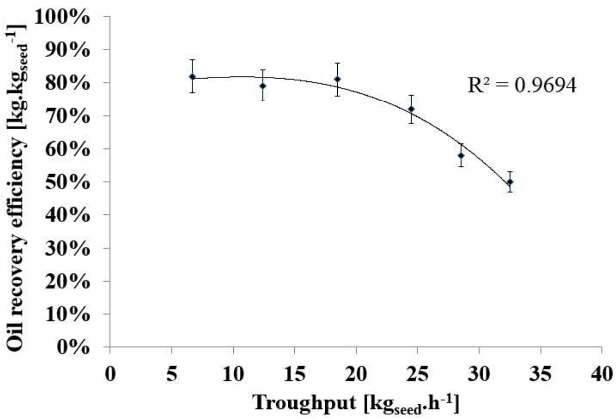

Figure 4. The effect of seed material troughput on oil obtained ratio.

Measured values of oil efficiency (η_{oil}) were fitted by exponential curve using Marguardt Levenberg algorithm and it is described by Eq. 3.

$$\eta_{oil} = 85.114 - 0.613 \, . \, e^{\left(\frac{TP}{8.345}\right)} \tag{3}$$

The model can be also used only for the given troughput (5–35 kg h^{-1}) and mechanical screw press (Farmer 20).The oil recovery efficiency reached high values of around 85% for a troughput up to 20 kg h^{-1}. On the other hand there is an increase in specific energy at low values of troughput. For low screw rotation speeds, the energy value reaches about 2.3 kWh kg_{oil}^{-1}. Similar values of oil recovery were also determined for flax seeds (Zheng et al., 2005).

CONCLUSIONS

Power input of press was decreased when rotational speed of screw was higher. Oil recovery efficiency and specific mechanical energy were decreased when the seed material troughput was increased. Maximum oil recovery efficiency 82.6% was at the lowest screw speed. The optimal operation point for screw press Farmer 20 – duo was at 20 kg h^{-1} rapeseed throughput. The specific mechanical energy at the optimal operation point, which was determined by Eq. 2, was 0.61 kWh kg_{oil}^{-1} and oil recovery efficiency 76.3%. The oil extraction efficiency was described and achieved the study objectives. Future studies should focus on analysing different press settings, nozzle diameter and physical properties of the input material as well as temperature influence on oil and press cake quality.

ACKNOWLEDGEMENT. This paper has been supported by Internal Grant Agency of Faculty of Engineering – Czech University of Life Sciences Prague – IGA 2018: Impact of technical and economic parameters of agricultural product drying in Indonesia with regard to quality of production and economic impact on local market.

REFERENCES

ASAE S410.1 DEC97. 1998. Moisture measurement of peanut. In: ASAE standards, 45th edition. 560–561.

Crowe, T.W., Johnson, L.A. & Wang, T. 2001. Characterization of extruded-expelled soybean flours. *Journal of the American Oil Chemists' Society* **78**, 775–779.

Evon, P., Vandenbossche, V., Pontalier, P.Y. & Rigal, L. 2009. Aqueous extraction of residual oil from sunflower press cake using a twin-screw extruder: Feasibility study. *Industrial Crops and Products* **2**, 455–465.

Evon, P., Amalia Kartikac, I., Cerny, M. & Rigala, L. 2013. Extraction of oil from jatropha seeds using a twin-screw extruder: Feasibility study. *Industrial Crops and Products* **47**, 33–42.

Herak, D., Sleger, V., Mizera, C. & Sedlacek, A. 2015. Mechanical behaviour of bulk rapeseeds under quasi dynamic compression loading. *Engineering for Rural Development* **14**, 28–32.

Isobe, S., Zuber, F., Uemura, K. & Noguchi, A. 1992. A new twin-screw press design for oil extraction of dehulled sunflower seeds. *Journal of the American Oil Chemists' Society* **69**, 884–889.

Kabutey, A., Herak, D., Choteborsky, R., Dajbych, O., Sigalingging, R. & Akangbe, O.L. 2017. Compression behaviour of bulk rapeseed: Effects of heat treatment, force, and speed. *International Journal of Food Properties* **20**, 654–662.

Karaj, S. & Müller, J. 2011. Optimizing mechanical oil extraction of Jatropha curcas L. seeds with respect to press capacity, oil recovery and energy efficiency. *Industrial Crops and Products* **34**, 101–1016.

Marquardt, D.W. 1963. An Algorithm for Least-Squares Estimation of Nonlinear Parameters. *Journal of the Society for Industrial and Applied Mathematics* **11**, 431–441.

Pritchard, P.J. 1998. Mathcad: A tool for engineering problem solving. McGraw-Hill Science Engineering, New York, 336 pp.
Singh, J. & Bargale, P. 1990. Mechanical expression of oil from linseed (*Linum usitatissimum L*). *Journal of Oilseeds Research* **7**, 106–110.
Singh, K.K., Wiesenborn, D.P., Tostenson, K. & Kangas, N. 2002. Influence of moisture content and cooking on screw pressing of crambe seed. *Journal of the American Oil Chemists' Society* **79**, 165–170.
Uitterhaegen, E., Nguyen, Q.H., Sampaio, K.A., Stevens, C.V., Merah, O., Talou, T., Rigal, L. & Evon, P. 2015. Extraction of Coriander Oil Using Twin-Screw Extrusion: Feasibility Study and Potential Press Cake Applications. *Journal of the American Oil Chemists' Society* **92**, 1219–1233.
Uitterhaegen, E & Evon, P. 2017. Twin-screw extrusion technology for vegetable oil extraction: A review. *Journal of Food Engineering* **212**, 190–200.
Zheng, Y., Wiesenborn, D.P., Tostenson, K. & Kangas, N. 2003. Screw pressing of whole and dehulled flaxseed for organic oil. *Journal of the American Oil Chemists' Society* **80**, 1039–1045.
Zheng, Y., Wiesenborn, D.P., Tostenson, K. & Kangas, N. 2005. Energy analysis in the screw pressing of whole and dehulled flaxseed. *Journal of Food Engineering* **66**, 193–202.