PARAMETERS OF HEMP OIL FILTRATION USING A PLATE FILTER

Jiří SOUČEK[1], Petr JEVIČ[1], Martin DĚDINA[1], Veronika TOMÁNKOVÁ[1], Kornél SZALAY[2], Vladimír MAŠÁN[3], Algirdas JASINSKAS[3]

[1]Research Institute of Agriculture Engineering, 161 01 Prague 6 , Czech Republic; jiri.soucek@vuzt.cz
[2]Hungarian University of Agriculture and Life Sciences , Institute of Technology, Páter Károly utca 1, 2100, Gödöllő, Hungary, Szalay.Kornel@uni-mate.hu[3]Department of Horticultural Machinery,
[3]Faculty of Horticulture, Mendel University in Brno, Valtická 337, 691 44 Lednice, Czech Republic; vladimir.masan@mendelu.cz
[4]Department of Agricultural Engineering and Safety, Faculty of Engineering, Agriculture Academy, Vytautas Magnus University

Abstract
The article is focused on determining the effect of pressure on the filtration parameters of vegetable oils. The experiments were carried out with hemp oil on an experimental filter device. The main part of the filter equipment is the Farmet plate filter. The monitored parameters were measured online using sensors and the COMET MS6D measuring center. The filtration rate was mainly influenced by oil pressure and filter pressure loss. It changed due to clogging of the filter membrane. A temperature change in the range of 15 - 25 °C had no effect on the filtration rate.

Key words: *vegetable oil; oilseeds; oil processing; filtration.*

INTRODUCTION

The fibrous plants, which include seeded hemp, are traditional crops grown in Central Europe. Their importance historically consisted in the use of fibers suitable for further processing. By the experience (*Mendel et al, 2020*) hemp can be well used as part of phytoremediation procedures or as an energy raw material (*Souček & Jasinskas, 2020; Malaťáková, J., et al., 2021*). Currently, hemp seed is an important raw material. In practice, it is most often used as part of human nutrition, or feed. It is most often used in peeled form, or pressed in the form of hemp oil and crumbs. The high dietary value of hemp seeds and oil, which contains a significant amount of unsaturated fatty acids, is appreciated. Unfortunately, this advantage results in low oxidation stability (*Kyselka et al., 2017*). To obtain quality oil, the main operations are storage, pressing and filtration. The parameters of these operations have a fundamental influence on the composition and quality of the oil.

According to the literature (*Tura et al., 2022; Vitorovič et al., 2021*), hemp oil is valued primarily for its nutritional properties, which are associated with beneficial health effects. Hemp seeds contain up to 35% fatty acids, a high proportion of protein (25%), carbohydrates (30%) and fiber (10%). Hemp oil is rich mainly in linoleic and linolenic acid in a suitable ratio for nutrition. Linolenic acid gives hemp oil a higher nutritional value. The main production of hemp oil is concentrated in Canada, where, thanks to more modern procedures, the unwanted content of the psychoactive substance THC (Tetrahydrocannabinol) is reduced.

The hemp seed can be stored relatively well if the right conditions are maintained. It is important to ensure the correct temperature and humidity of the storage atmosphere. It is advisable to aerate the stored seed layer regularly and prevent damage during handling. The next step in processing is pressing, usually on screw presses. The temperature of the oil at the outlet of the press should not be higher than 50 °C. Oxidative stability is most often defined in the literature (*Bárta et al., 2021*) by the value of the peroxide number and the acidity number.

Virgin hemp oil has a high content of unsaturated fatty acids. If technological discipline is observed during its processing, it retains all nutritionally important substances and does not contain the psychoactive substance THC. On the sensory side, hemp oil has a slightly nutty smell and a light green color.

Aim of this research was to verify the effect of filtration conditions on the operating parameters and properties of the filtered oil and thus contribute to the improvement of the processing quality of vegetable oils.

MATERIALS AND METHODS

Unfiltered hemp oil of the Bialobrzeskie variety grown in the village of Částrov (Vysočina region, Czech Republic) was used for the implementation of the experiment. The harvested seed was subjected to post-harvest treatment and stored for 30 days. It was subsequently pressed on a low-tonnage screw press Farmet Duo (Farmet, s.r.o., Czech Republic) at an outlet oil temperature of 43 ± 3.5 °C. The pressed oil was stored for four days at a temperature of 8 ± 1.2 °C. During storage, the solid part (sludge) naturally separated from the liquid part by gravity. As part of the analytical analysis (elemental composition), these parts were analyzed separately and subsequently subjected to experimental filtration.
For the experimental determination of the filtration curves of the investigated samples, the VÚZT experimental equipment was used (fig. 1). The basis of the device is the FARMET plate filter (Farmet, s.r.o., Czech Republic).

Fig. 1 Experimental device for measuring filtration

For the measured samples, the agrochemical laboratory of VÚZT determined their properties important from the point of view of further use.
- Analytical composition (about EN 15297:2011, ISO 16948:2015) [38,39].
Microbiological analyzes of the total number of microorganisms, mold and yeast content (ČSN EN ISO 4833, ČSN ISO 21527-1,2, ČSN ISO 16649-2 and ČSN EN ISO 7899-2).
- Oxidative stability of the oil expressed by the value of the peroxide number (ČSN EN ISO 3960). The peroxide number value was determined in the stored oil before starting the experiments. In the tested oil before entering the filter and at the exit from the filter.
- Determining the content of impurities microscopically.
- Measurement uncertainties are determined according to documents ČIA European cooperation for accreditation EA 4/02. Measuring devices meet the requirements of ČSN EN ISO/IEC 17 025.

The experimental device enables the setting of operating parameters and online sensing of monitored physical quantities at nodal points. For uniform flow, the device is equipped with a system of adjustable static oil pressure in the range of 0-300 kPa (limited by the filter design).
During the experiment, the oil is pushed through the membrane by static pressure into the plate filter. The pressure is set to the desired level before the start of the experiment.
The flow rate is determined by mass using a KERN FTC 60K2 tensometric balance with a measuring range of 60 ± 0.002 kg with a digital on-line output.
The oil pressure before the filter is measured using a Greisinger DMP 331 110 pressure transducer with a measuring range of 0...1600 ± 40 kPa.

The oil temperature is measured by jacketed thermocouples type K*0.25 mm with a time constant*1 s. The oil temperature is measured in the inlet reservoir, at the filter inlet, at the filter outlet and in the outlet reservoir. The relative humidity and temperature of the surrounding air is measured by the Testo 6651 temperature and humidity converter (accuracy ± 0.5°C, ± 2.5% RH) during the experiments. All the listed gauges are connected to the COMET MS6D measuring and recording center as well as the weight measurement.
All data were recorded using the COMET MS6D control unit with a set interval during online connection with a PC or in recording mode with subsequent data export to a PC.
As part of the experiments, oil filtration curves at constant pressure were determined. A sample of 15 kg of oil was prepared when measuring the filter curves. The sample was released from the storage container by gravity into the inlet reservoir and after stabilization was released into the storage pressure vessel. After setting the desired pressure value, the filter inlet pipe was filled with the sample. If necessary, excess air was removed with the help of a venting valve, and then the recording of values was started. The measured values could be monitored online on a PC connected to the measuring station. A sample of material was considered filtered if the measured oil flow was zero for 30 seconds.
The measured data were processed in the MS Excel program and statistically evaluated in the STATISTICA program.

RESULTS AND DISCUSSION

Table 1 shows the results of elemental analysis of oil and sludge.

Tab. 1 Composition of hemp oil and sludge according to analytical analysis

Parameters	Value, %	
	oil	sludge
amount of carbon, %	68.07 ± 1.12	77.86 ± 1.14
amount of hydrogen, %	10.15 ± 0.45	11.31± 0.42
amount of sulphur, %	0.26 ± 0.001	0.08± 0.001
amount of nitrogen, %	1.82 ± 0.1	0.05± 0.001
amount of chlorine, %	0.069 ± 0.004	26± 0.004
amount of silicon %	0.80 ± 0.003	0.24± 0.004
amount of calcium, %	0.253 ± 0.025	<0.07
amount of magnesium, %	<0.05	<0.04
amount of potassium, %	0.814 ± 0.016	0.07± 0.020
amount of phosphorus, %	0.650 ± 0.004	0.005± 0.002
amount of zinc, mg/kg	0.002 ± 0.75	0.002 ± 0.75
amount of cadmium, mg/kg	<0.2	<0.2
amount of lead, mg/kg	<0.002	<0.002
amount of chromium, mg/kg	<0.002	<0.002
amount of copper, mg/kg	<0.001	<0.001

The oil was subsequently subjected to microbiological analyses. These were carried out for the content of the total number of microorganisms, the number of yeasts and molds, Escherichia coli and intestinal enterococci. The results according to the analysis of the VÚZT microbiology laboratory are shown in Table 2.

Tab. 2 Results of the microbiological analysis of the oil

Parameters	Value
total number of microorganisms, CFU/ml	< 10
yeast and mold count, CFU/ml	< 10
Escherichia coli, CFU/ml	0
intestinal enterococci, CFU/ml	0

The figures 2 and 3 graphically show examples of the filter curves at set pressure values of 200 and 250 kPa. The pressure in the system was maintained at the set value using a pressure reducing valve with an accuracy of ± 10 kPa. The temperature of the sample increased slightly during filtration due to the increased pressure.

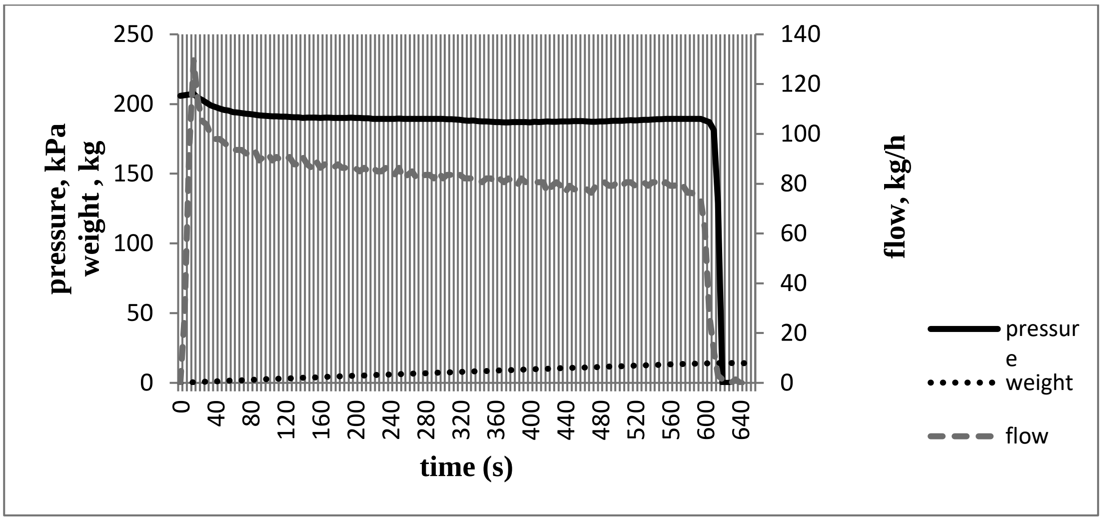

Fig. 2 Graphic representation of the course of oil pressure, flow through the plate filter and the weight of filtered oil within the experiment – 200 kPa

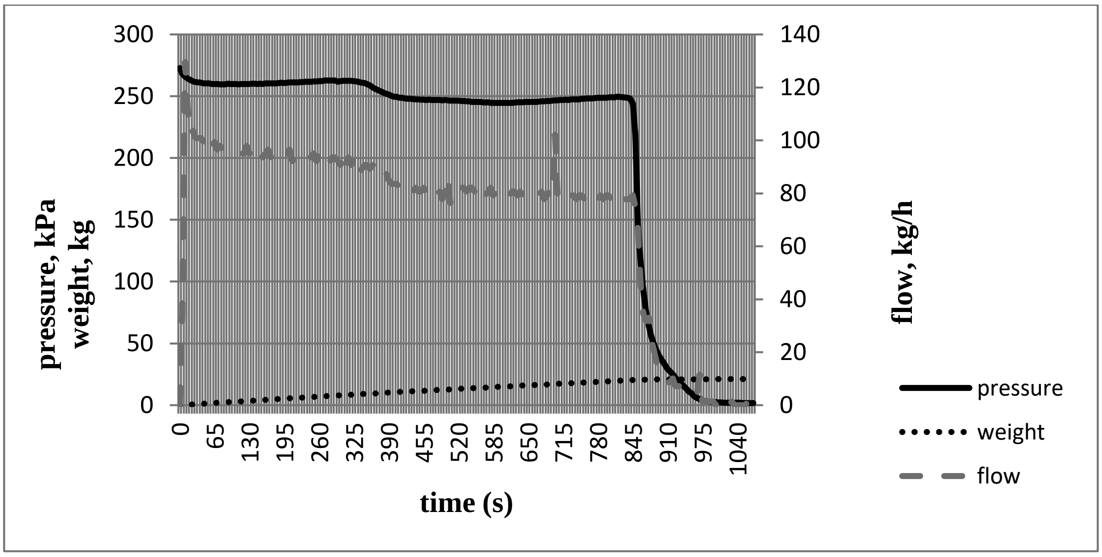

Fig. 3 Graphic representation of the course of oil pressure, flow through the plate filter and the weight of filtered oil within the experiment – 250 kPa

It is clear from the graphs in Figures 2 and 3 that the greatest flow through the filter was recorded at the beginning of the measurement. During the experiment, it gradually decreased due to the sludge clogging of the filter plates.

The filtration parameters for other pressure values in the range of 0-250 kPa were determined in the same way as in the given examples. The dependence of oil flow through the filter on its pressure is shown in Figure 4.

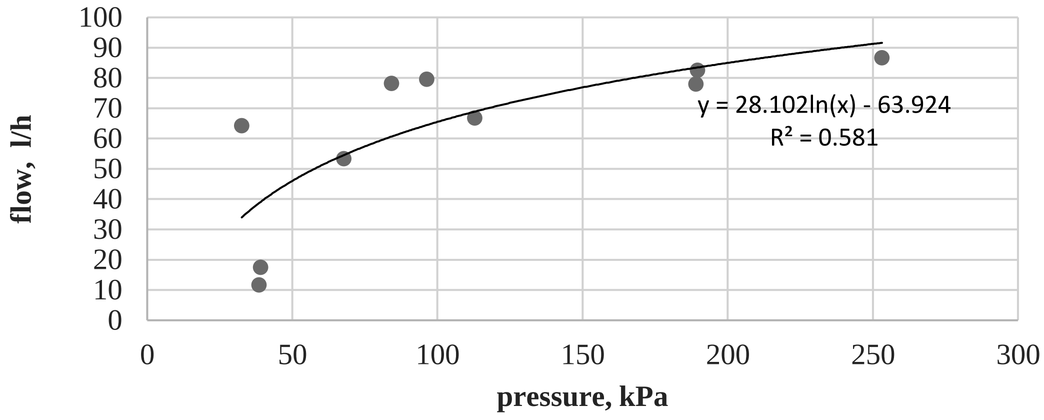

Fig. 4 Dependence of filtered oil flow on pressure - filter N 15-25

From the results in Figure 4, it is clear that the pressure change at a lower level (up to approx. 100 kPa) has a greater influence on the flow value. When the pressure changes above approx. 150 kPa, the change in the flow is no longer evident - it is so significant, as well as in literature (*Guerrini et al., 2020*). Minor discrepancies are caused by differences in the temperature of the filtered oil and the level of filter clogging (pressure losses). This finding is consistent with (*Yamamoto and, Toda, 2018*).

Another monitored parameter was the oil temperature, while in the monitored range of 15-25 °C, the temperature had no significant effect on the filtration rate. The stated temperature range was within the range also stated by According to the literature (*Vitorovič et al., 2021*). According to the literature (*Kyselka et al., 2017*), the temperature in the specified range has no effect on the quality parameters of the oil. Logically, however, it can be assumed that with larger temperature differences, the viscosity of the oil will change more significantly and the effect on the flow value will also be more pronounced. Verification will be the subject of further research.

CONCLUSIONS

The measurement results show that when filtering vegetable oils on plate filters, the oil pressure is a decisive factor for the filtration speed. Higher pressure is supposed to result in faster oil flow. In the area of lower pressures (up to 100 kPa), the effect of pressure on flow is more significant than at higher pressures. The upper limit of the applied pressure is given by the constriction solution of the filter.

Another important aspect that affects the material flow is the gradual clogging of the membranes during the formation of the filter cake. With a higher layer, the pressure drop increases and the flow decreases.

In the monitored temperature range of 15 – 25 °C, no statistically significant effect on the oil flow through the filter was recorded.

The achieved results confirmed the predicted expectations. At this moment, the knowledge can be used and the conclusions can be drawn for operations processing plant sludge for technical purposes. In order for recommendations to be formulated also for the areas of food industry, pharmacy, etc., the experimental activity will continue with the fact that the research will be focused on questions of the effect of the filtration process on the composition and oxidative stability of oils.

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Corresponding author:
Ing. Jiří Souček, Ph.D., Research Institute of Agriculture Engineering, 161 01 Prague 6 , Czech Republic; phone: +420 233022214, e-mail: jiri.soucek@vuzt.cz