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SELECTION AND OPTIMIZATION OF THE MAIN PARAMETERS OF THE TECHNOLOGY OF "COLD PRESSING" OF SUNFLOWER SEEDS IN A HYDRAULIC PRESS

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Abstract

The paper studies the influence of the main process parameters (pressing pressure and particle size of oilseed material) during cold hydraulic pressing on the residual oil content of the cake and the acid number of oil from local varieties of sunflower seeds. Using the nonlinear programming optimization method, it was found that, at a pressing pressure of 50 MPa and a petal thickness of oilseed material of 0.3 mm, the residual oil content of the cake will be within 6.5%; and the acid number of the resulting oil will be within 1.4 mg KOH/g.

Keywords: *sunflower seeds, oil, pressing, hydraulics, pressure, thickness of the petal sunflower seeds, residual oil content of the cake, acid number*

Introduction

Cold pressing of oilseeds in a hydraulic press is a process in which oil is extracted from the seeds of various oilseed crops (such as sunflower, flax, sesame, and others) without the use of heat. This method allows preserving the maximum amount of nutrients and vitamins in the oil, since in the absence of high temperatures, the beneficial substances are not destroyed (Kopylov, M.V., 2013; Proctor, A., 2013).

The main stages of the cold pressing process: seed cleaning; seed preparation for pressing; pressing; oil purification.

Advantages of cold pressing: preservation of natural antioxidants, vitamins (especially E) and fatty acids (e.g. omega-3, omega-6). The oil has a more pronounced taste and aroma, characteristic of the original raw material. No chemical additives or solvents (Çakaloğlu, B., Özyurt, V. & Ötleş, S., 2018).

Disadvantages: lower oil yield compared to hot pressing or solvent extraction. The process may be slower and less cost-effective (Çakaloğlu, B., Özyurt, V. & Ötleş, S., 2018).

The main factors affecting the oil yield during hydraulic pressing include (Gafurov, K. Kh., Safarova, D. N., 2022; Mustafaev, S. K., Kalienko, E. A., Sonina, D. V., & Efi-

menko, S. G., 2014; Çakaloğlu, B., Özyurt, V. & Ötleş, S., 2018):

1. Raw material moisture: the moisture content and maturity of the raw material also play a role. Raw materials with the right moisture content will maximize oil yield, while those that are too dry or too wet may reduce efficiency.

2. Size and shape of raw material particles: finer grinding of raw material is easier to press, as oil is released more easily from small particles. However, excessive grinding can lead to the formation of too dense a mass, which complicates the extraction of oil.

3. Temperature and pre-treatment of raw materials: heating the raw material before pressing reduces the viscosity of the oil and increases its flowability, which helps increase the yield. Too high a temperature can lead to oxidation of the oil, deterioration of quality and losses. Methods such as heating, wet-heat treatment or fermentation can increase the yield of oil by breaking down the cell walls and facilitating pressing.

4. Pressing pressure: The higher the pressure, the more oil can be extracted. However, excessive pressure can lead to the destruction of the cellular structure of the raw material and a decrease in oil yield.

5. Duration of pressing: The longer the pressing, the more oil can be extracted, but at a certain point, additional effort does not significantly increase the yield, since most of the oil has already been extracted.

The correct combination of these factors allows for the most efficient extraction of oil during hydraulic pressing.

The purpose of this stage of the work is to study the influence of the main factors during hydraulic pressing on the residual oil content of the cake and the acid number of sunflower oil, with the subsequent determination of the optimal values of the influencing factors.

Object and methods of research. The object of the study was the seeds of the sunflower hybrid Dushko, included in the State Register of Agricultural Crops Recommended for Sowing in the Republic of Uzbekistan. Before pressing, the sunflower seed meal was treated with IR rays with a heat flux density of 7.2 kW/m^2 andan irradiation duration of 60 s in the mode:

+60–120+35–120+35–120+35–120+30 (the "+" sign indicates the duration of IR irradiation; the "-" sign indicates the duration of exposure without irradiation) (Gafurov, K.Kh., Safarova, D.N., 2022; Gafurov, K. Kh., 2020).

The temperature of the raw material under this heat treatment regime does not reach 60 °C, and the humidity of the raw material is 6%, which is optimal for cold pressing (Cai, Z., et al., 2021).

6YZ –230 hydraulic press was used to extract the oil by pressing. Hydraulic presses for cold pressing are distinguished by the fact that they create high pressure using hydraulics, which allows for the oil to be extracted carefully without a significant increase in temperature.

The residual oil content of the cake was determined according to the state standard *O'z DSt 2438:2012* Oil seeds. Methods for determination of oil content.

The acid number of the oil was determined according to the state standard *O'z DSt 1203:2015* Vegetable oils. Methods for determination of acid number.

The study used the compositional design of experiments method (Murray P. M., et al. 2016; Georgakis C., 2013).

Analysis of results. For the study, we select the pressing pressure and the particle size of the raw material as influencing factors. The pressure of the hydraulic press plays an important role in obtaining vegetable oil, since it helps to extract oil from seeds or fruits. The pressure required for pressing oil varies depending on the type of process and the purpose of production, but it is usually from 20 to 70 MPa. We select the limiting pressure values $z_1^- = 40$ MPa; $z_1^+ = 60$ MPa.

The particle size of the raw material during hydraulic pressing plays a key role in the efficiency of the oil extraction process. The correct particle size during hydraulic pressing must be carefully selected for each type of seed. The optimal size ensures both efficient oil extraction and minimal oil loss in the cake. To achieve maximum oil yield, it is important that the seed particles are small enough to break down the cellular structures, but not too small to form a dense, poorly permeable mass. Typically, for sunflower pressing, the particle size after grinding is about 0.2–0.5 mm.

We select the boundary dimensions of sunflower seed meal (petal seeds): $z_2^- = 0.2\ mm\ z_2^+ = 0.4\ mm.$

The output parameters are the residual oil content of the cake, y_1, %, and the acid number of the oil, y_2, mg KOH/g.

The results of the experiments were processed using mathematical and statistical methods. To assess the homogeneity of variances with an equal number of repetitions of each experiment, the Cochran criterion was used, the significance of the coefficients of the empirical model was determined using the Student criterion, and the adequacy of the equations was proven using the Fisher criterion (Murray P. M. et al., 2016; Georgakis C., 2013).

Empirical models in coded values of influencing factors were obtained in the following form.

For residual oil content of oil cake:

$$y_1 = 3.91 - 3.40x_1 - 0.26x_2 - \\ -0.18x_1x_2 + 2.03x_1^2 - 0.29x_2^2 \quad (1)$$

For acid number of oil:

$$y_2 = 1.96 + 0.15x_3 + 0.4x_4 - 0.3x_3^2 + 0.191x_4^2 \quad (2)$$

We write out mathematical models in natural values of variables, substituting their expressions through z_i instead of x_i. After performing arithmetic operations, we obtain an equation in natural values of influencing factors:

For residual oil content of oilcake:

$$Y_1 = 67.13 - 2.316z_1 + 23.8z_2 + \\ +0.0203z_1^2 - 29.0z_2^2 - 0.18z_1z_2 \quad (3)$$

For acid number of oil:

$$Y_2 = -5.771 + 0.315z_1 - \\ -7.46z_2 - 0.003z_1^2 + 19.1z_2^2 \quad (4)$$

We designate the optimality criteria.

Optimality criterion for residual oil content of oilcake: $Y_1 = f(z_1, \ z_2) \to Y_{1\min}$.

Optimality criterion for the acid number of the oil: $Y_2 = f(z_1, \ z_2) \to Y_{2\min}$.

Corresponding problem is to study the possibilities of using different optimization methods (Pen, R.Z., Pen V. R., 2022; Kashtaeva, S.V., 2020).

Nonlinear programming methods are used to solve optimal problems with nonlinear objective functions. The nonlinear programming method combines a large group of numerical methods, many of which are adapted to solve optimal problems of the corresponding class. A number of nonlinear programming methods are almost always used in combination with other optimization methods (for example, with the scanning method in dynamic programming).

The scanning method consists of sequentially viewing the optimality criterion in a number of points belonging to the range of variation of independent variables, and finding among these points the one in which the optimality criterion has a maximum (minimum) value. The accuracy of the method is naturally determined by how "densely" the selected points are located in the permissible range of variation of independent variables (Pen R. Z., Pen V. R., 2022; Kashtaeva S. V., 2020).

The quality of the final oil is inextricably linked to the condition of the sunflower seeds used. Proper preparation is paramount to maximizing oil yield and minimizing the presence of undesirable compounds in the finished product. Key aspects of raw material preparation include:

- **Seed Cleaning:** Removal of foreign materials (e.g., dust, stones, weeds) is crucial. This prevents damage to the press, contamination of the oil, and uneven pressing. Effective cleaning methods might involve sieving, aspiration, and magnetic separation;
- **Seed Dehusking (Optional):** While not always necessary, dehusking (removing the seed hull) can improve oil yield. The hull absorbs some oil, and its removal reduces the overall pressure required during pressing, potentially increasing the efficiency of the process. Dehusking can be achieved mechanically, using dehulling machines;
- **Seed Crushing/Flaking:** This step significantly increases the surface area of the seeds, allowing for better oil extraction. Crushing or flaking should be done to a degree that maximizes surface area without creating excessive fines (small particles) which can clog the press. The desired size and consistency of the flakes will de-

pend on the specific press and seed characteristics. Roller mills and hammer mills are commonly used for this purpose;

- **Seed Moisture Content:** Optimal moisture content is vital. Too much moisture can lead to lower oil yield and potential microbial growth, while excessively dry seeds can be difficult to press and may result in higher energy consumption. The ideal moisture content typically ranges from 6–8%, though this can vary slightly depending on seed variety and press characteristics.

Cold pressing of sunflower seeds is a popular method for producing high-quality sunflower oil, prized for its retention of beneficial nutrients and its characteristic flavor profile. This process, unlike hot pressing or solvent extraction, avoids high temperatures that can degrade the oil's quality. However, achieving optimal oil yield and quality in cold pressing requires careful selection and optimization of several key parameters within the hydraulic pressing process.

To determine the optimal values of factors influencing the yield and acid number of sunflower oil, a calculation program was compiled in the *Delphi* algorithmic language.

Conclusion

Thus, under appropriate conditions, the minimum values of residual oil content of the cake after cold hydraulic pressing and the acid number of the oil will be obtained at a pressing pressure of z_1 = 50 MPa and a seed meal (petal seeds) thickness of z_2 = 0.3 mm. In this case, the residual oil content of the cake is 6.5%, the acid number of the oil is 1.4 mg KOH/g. The obtained data on the optimal operating parameters of the pressing process are necessary for the implementation of this process under production conditions.

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