Resource-saving technology of two-stage pressing in the production of rapeseed oil

I V Matskevich, V N Nevzorov, A V Kolomeitsev and S A Kapsargina

FSBEI HE Krasnoyarsk State Agrarian University, 90, Mira Av., Krasnoyarsk, 660049, Russia

E-mail: imatskevichv@mail.ru

Abstract. Technical solutions are presented in the article aimed at improving the efficiency of the technological process of production for vegetable oil and obtaining feed additives for farm animals and poultry from the spring rapeseed, cultivated in the Krasnoyarsk Territory with a high oil content of 38-40%. The authors describe a resource-saving technology that provides for two-stage pressing of oilseed raw materials and obtaining high-quality edible rapeseed oil by two-stage cold pressing of oil from seed cake using screw and piston presses combined in one unit of technological equipment. The developed technology is compared with the double-pressing technology that is used widely in modern processing plants. The key technical solutions are highlighted according to completed analysis, which implementation improves the production efficiency of rapeseed two-stage pressing process for 12%. It also reduces electricity consumption by 8%, increases the yield of rapeseed oil from the cake by reducing the residual oil content in oil cake to 3-5%. The developed technical means are intended for introduction into the production of rapeseed processing scheme for micro - and small agricultural enterprises. It is established that the use of the developed resource-saving technology reduces the cost of rapeseed oil production in comparison with existing technologies for processing oilseeds up to 6-8%, depending on the oil content of the seeds.

1. Introduction

Agricultural crop of spring rapeseed in the natural and climatic conditions of the Krasnoyarsk Territory was spread widely in the early of the 21st century. If in 2005, the area of spring rapeseed crops was 4.1 thousand hectares, in 2018, the acreage was 114 thousand hectares, and in 2019, it is already 145 thousand hectares. The increase in planting acreage of spring rape is due to the fact that the rapeseed crop has universal use and finds wide application in fodder production and is also used as green manure. In the flowering period it is possible to gather honey in the amount of 80-100 kg per 1 ha and rapeseed issued for production of edible rapeseed oil and biofuel [2].

It should be emphasized that the Krasnoyarsk Territory is included in region №11 "East-Siberian", only 25 varieties and hybrids of spring rapeseed 55 REGION, CYCLUSCL, CEBRACL, DRAGO, CURRYCL, LUMAIN, SIBIRSKY, FLAGMAN, ARBALET, MIRACLE, FORWARD, ERMAK, OREDEZH 4, RUBEZH, ANIIZIS 2, YUBILEINY, RATNIK, NADEZHN 92, LIPETSKY, OREDEZH 2, RADIKAL, ANIIZIS 1, DUBRAVINSKYFAST RIPENING, LUGOVSKOY are approved for cultivating on the territory.

Varieties of spring rape approved for use in the Krasnoyarsk Territory have the following characteristics and features:
- seed germination at a temperature of +1+5 °C (the optimal germination temperature is +12+15 °C);
- frost resistance of seedlings is -3-5 °C;
- resistance of adult plants to frost is -8°C;
- requirements for heat in the summer months are at the level of +18 + 20 °C (during the flowering period at +20+25 °C);
- the required amount of temperatures for the growing season is 1700-2100 °C;
- the ability to guarantee yield on moderately saline soils with the reaction of the soil environment 6,3-7,7;
- the fat content in seeds is 39.8-47.6% [1].

At the same time, with the increase in production of oilseeds on the territory of the Krasnoyarsk Territory, there is a problem of developing new highly efficient resource-saving and cost-effective technologies and equipment for processing seeds for high-quality food oil, as well as the needs of the agro-industrial complex in the production of biofuels and seed cake with low residual oil content for feeding farm animals and poultry.

Currently, processing plants use widely technologies for cold pressing of oilseed rape seeds, the technological process consists of double pressing using two separate dimensional oil presses exercising intermediate equipment to move the cake from one press to another. Existing technologies using two screw presses are used for processing rapeseed with an oil content of more than 30% [5,6]. The main disadvantage of the used technology is increased metal consumption of the equipment due to the use of two separately operating presses which increases energy costs and increases the time of the performing of working operations for the production of rapeseed oil, which further reduces the economic efficiency of the production process. The authors developed and patented in the Russian Federation resource-saving small-sized equipment that allows the use of two-stage pressing technology in the production of rapeseed oil on one unit of equipment [3].

2. The purpose of the study
The purpose of this study is to develop a resource-saving technology and technical means to improve the efficiency of the process of pressing rapeseed oil for micro-and small-scale agricultural businesses.

3. The object of the study
The object of the study is the process of cold pressing of small-seed oil containing raw materials, using the two-stage pressing technology.

4. Materials and methods
A comparative analysis of the implementation of existing and developed technologies was carried out at the initial stage of the research to determine the design differences and to identify the inefficiency of the press equipment. To improve the efficiency of the technological process and the development of new equipment, the results of patent research performed in accordance with STST R 15.011-96 “Patent research” were used. The system of development and delivery of products for the production of a pilot sample was carried out using the method of mathematical modeling of the technological process. The research content and procedure were carried out using a computer, a table processor "Microsoft Excel", a computer simulation program.

Tests of an experimental sample using the technology of two-stage pressing of oilseed rapeseeds were conducted in the laboratory of the Institute of Food Production on the basis of normative documents «Tests of agricultural machinery. Test program and methods”.

5. Discussion of the results
Figure 1 shows a comparative technological scheme for processing rapeseed seeds by double cold pressing. According to the existing technology, at the first stage, the oil is pre-pressed on the screw
press, and the resulting oil cake is fed by an open conveyor to the screw press for final pressing. Therein, the residual oil content of the cake is 10-12%.

According to the author's resource-saving technology for processing rape seeds, at the first stage, the oil is pre-pressed on the screw press, the resulting seed cake at the exit of the screw press is loaded into the working cylinder of the piston press where the final oil is pressed, the residual oil content of the resulting cake is 3-5%.

**Figure 1.** The comparative technological scheme of rapeseeds processing

For implementation of the technological process based on the developed resource-saving technology for the production of edible rapeseed oil by cold pressing, a new design of the universal oil press was developed (figure 2), the copyright is protected by the patent of the Russian Federation, No. 192240, "Hydraulic press for oilseeds" [4].

**Figure 2.** Kinematic diagram of the universal oil press
The developed design of the universal oil press consists of an electric drive 1, a loading hopper 2, a molder chamber 3, a screw press 4, an oil collector 5, a hydraulic drive 6, a piston 7, a pressing chamber 8, an oil collector 9, and a regulating device 10.

According to the kinematic scheme shown in figure 2, normative and design documentation was developed and a pilot experimental installation universal oil press was manufactured, the general view of which is shown in figure 3.

![General view of the universal oil press](image)

**Figure 3.** General view of the universal oil press

The universal press works as follows: the seeds of oilseeds are loaded into the hopper 7, the control unit 2 activates the electric motor of the screw press drive 4, through the belt drive 5, and the torque is transmitted to the reducer of the screw press drive 8 and the belt drive of the feeder 6. From the reducer of the screw press drive 8, the screw installed in the molder chamber 9 is activated, the gap at the exit of the molder chamber is regulated by the mechanism 10. After the first stage of cold pressing of seeds in the molder chamber 9, the pressed oil is collected in a container 16, and the oil cake is loaded into the working cylinder of the piston pressing 13. After filling the cylinder 13 with the cake, the operation of the screw press stops and the hydraulic press control unit 3 starts the high-pressure hydraulic station 11 and the hydraulic cylinder 12 is pressed through the piston of the hydraulic press 14 after the end of pressing in the hydraulic press, pressing in the screw press begins and the cycle repeats.

According to the results of the study, the expected economic effect of using a universal press for the production of rapeseed oil in the oil processing industry, manufactured under Russian patent No. 192240 "Hydraulic press for oilseeds", was done using the method of determining the economic efficiency of using new equipment, inventions and innovation proposals in the national economy.

The annual economic effect is 7303800 and is defined as the amount of savings in all production resources (labor intensity, materials, capital investment) that production receives as a result of using new equipment.
6. Conclusion
A comparative analysis of existing technologies for extracting oil from cruciferous oilseeds has shown that the use of two presses and intermediate processing equipment in the technological process reduces the economic efficiency of oil production. The solution to the problem is to develop a new resource-saving technology for two-stage pressing using a single universal press for pressing oil using screw and piston pressing.

According to the developed author's technology, the total oil yield increases by 7%, while using the second stage of hydraulic piston pressing reduces the residual oil content of the cake to 3-5%, which allows it to be used for food for agricultural animals and poultry. The use of a combined screw and hydraulic press reduces metal consumption by 30% and energy consumption by 35%.

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