Technology of microwave treatment of cameline seeds and its economic efficiency

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Abstract. The purpose of the paper is a feasibility study on the effective implementation of microwave treatment technology for oilseeds during pre-sowing treatment and oil pressing while improving the quality of vegetable oil, including rapeseed, camelina and mustard oil, and increase in its production. The objectives of the study are calculation of the volume of extra products received, ensured by the application of the proposed technology; defining the oil quality parameters; development of methods for calculating the economic efficiency of the project; adaptation of methods for assessing the economic efficiency of an economic entity to the specifics of processing agricultural enterprises. The paper substantiates the possibility of implementing a project for the processing oilseeds using microwave technology in accordance with the requirements of the State Program for the Development of Agriculture and the regulation of the market for agricultural products, raw materials and food for 2013-2020 and the possibility of implementing the project, taking into account the obtaining grants by agricultural processing consumer cooperatives for the development of the material and technical base. The authors determined the effective treatment regime for camelina, rapeseed and mustard seeds during pre-sowing treatment and oil press. The characteristics of the oil, the treatment regime are presented. The expected increase in production provided by the implementation of the developed microwave technology is calculated. A methodology for the economic feasibility of the project is proposed and basic economic indicators are calculated that prove the economic efficiency of the project. Calculations and recommendations can be used by processing enterprises in order to increase economic efficiency by increasing production, as well as increasing productivity due to pre-sowing seed microwave treatment.

In the "State Program for the Development of Agriculture and Regulation of the Market for Agricultural Products, Raw Materials and Food" for 2013-2020 the goal is to ensure food security of the Russian Federation in the parameters set by the Food Security Doctrine of the Russian Federation [1].

The objectives of the program include stimulating an increase in production of the main types of agricultural products and food and processing industry products, including increasing the proportion of vegetable oil to 87.7%. Cameline oil is a valuable food product and is in demand both in the domestic and foreign markets.

The program of the Krasnoyarsk Region “Development of agriculture and regulation of raw materials and food markets” provides grants to compensate for the cost of elite oilseeds [2]. The technology of microwave treatment of camelina seeds during pre-sowing treatment and oil pressing
will improve the quality of these seeds, which will ultimately affect the increase in yield, as well as provide an increase in oil production and improve the quality of oil during processing.

The Krasnoyarsk Region Program provides grants to agricultural processing consumer cooperatives for the development of the material and technical base, including the purchase of equipment [2]. The implementation of the project of microwave treatment of camelina seeds in this regard seems promising.

According to open data, the gross collection of camelina seeds in peasant (farmer) farms and individual entrepreneurs, since 2011, has been steadily growing, and there are economic reasons for this:
- camelina seeds are unpretentious to the climatic conditions of Siberia;
- the cost of camelina seeds is growing in the world market, and, consequently, export of products is growing;
- camelina oil is becoming popular among consumers due to its healing and beneficial qualities.

One of the limiting factors for the cultivation of camelina and other oilseeds in the Siberian Federal District and, in particular, in the Krasnoyarsk Region and the Republic of Khakassia is seed infections and relatively low seed germination capacity.

For more than ten years, employees of the Krasnoyarsk State Agrarian University have been actively engaged in this problem. The effectiveness of the disinfection of oilseeds by the microwave electromagnetic field was investigated. According to the results of the study, the effective treatment regime for microwave treatment of camelina seeds was determined [3–6]; patents for inventions [3–6] were obtained.

As a result of the study, it was found that the “hard” mode: specific power \( P = 2548 \text{ W/dm}^3 \), treatment time in the microwave field 90 s, at a final seed heating temperature of 79.5°C, used in pre-sowing treatment of camelina seeds (option No. 1) [7; 8], proved to be an effective mode for heating seeds before oil press.

Oil and oilcake produced were analyzed according to the main quality indicators; the oil ratio was calculated depending on the temperature increase. The main quality indicators of the obtained products and the oil ratio according to the proposed method of seed treatment with microwave energy are shown in table 1.

**Table 1.** Indicators for different oilseeds during oil pressing (when heating seeds with microwave energy).

| Crop       | Maximum oil content of seeds in accordance with GOST | Estimated oil content of seeds at \( P = 2548 \text{ W/dm}^3 \), 90 sec, 79.5°C | Oil production from seeds using GOST press method, kg | Oil production from 1t of seeds during microwave heating, kg | Oil cost, rub/kg | Extra income from 1t of seeds, rub |
|------------|------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------------|----------------|-----------------------------|
| Rapeseed   | 42%                                                  | 50%                                                                            | 420                                        | 500                                             | 60             | 4800                        |
| Camelina   | 41%                                                  | 49%                                                                            | 410                                        | 490                                             | 90             | 7200                        |
| Mustard plant | 35%                                               | 42%                                                                            | 350                                        | 420                                             | 100            | 7000                        |

The economic efficiency of the implementation of the oilseeds microwave heating before press is that by increasing the temperature of the seeds to 70°C the oil production increases by 11.5% [10; 11].

With a decrease in the heating temperature of oilseeds in the microwave field to 50–60°C, the quality of the oil in terms of the peroxide value increases and the period of its safe storage increases. It was found that the specific power \( P = 1529 \text{ W/dm}^3 \), the treatment time in the microwave field of 90 s, at a final seed heating temperature of 59.6°C, corresponds to the "average" mode used in the pre-
Sowing treatment of camelina seeds (option No. 4) [6] proved to be an effective mode for heating seeds before oil press.

Studies have shown that when the seeds are heated before the oil press, the oil production increases by an average of 19%. The economic impact of the proposed microwave technology in comparison with the base is determined [9]:

\[ EI = D_1 + D_2 \]  

where \( D_1, D_2 \) — accordingly, extra income from an increase in the yield of oilseeds and from an increase in oil production, rub/year.

\[ D_2 = \Delta Q \cdot C \]  

where \( \Delta Q, C \) — accordingly, an additional oil production and its price.

The calculations were carried out in relation to the processing of 100 tons of camelina seeds per year. Net present value for 3 years when using microwave technology is determined:

\[ NPV = \sum_{t=0}^{T} (E_t - 3_t) \cdot \frac{1}{(1+E)^t} \]  

where \( 3_t = (K_t + M_t) \) — costs in the \( t^{th} \) year;

\[ \frac{1}{(1+E)^t} \] — discount coefficient.

Table 2 presents the economic indicators of the treatment of camelina seeds in the basic and microwave versions.

| Indicator                                      | Basic version | Microwave technology |
|------------------------------------------------|---------------|----------------------|
| The volume of processed camelina seeds, t     | 100           | 100                  |
| Oil production from 1t, kg                     | 410           | 490                  |
| Microwave investment, thou rub.               | -             | 1000                 |
| Annual operating expenses (including depreciation), thou rub/year | -             | 100                  |
| Net present value for 3 years, thou rub.      | -             | 715                  |

The calculations did not take into account the effect of increasing oilseeds yield due to pre-sowing seed treatment. When using a serial microwave installation at an enterprise, for example, AST-3 [10], the income can increase by three times, and the payback period of the installation will be within one to two years, depending on the volume of processed seeds.

The implementation of the project of microwave treatment of oilseeds meets the requirements of the State Program for the Development of Agriculture and Regulation of the Market for Agricultural Products, Raw Materials and Food for 2013-2020. The project can be implemented taking into account the use of grants included in the Program of the Krasnoyarsk Region "Development of Agriculture and Regulation of Raw Materials and Food Markets". When the seeds are heated before the oil press to a temperature of 79.5°C, the oil production increases by an average of 19%, the percentage in acid and peroxide numbers decreases, and the percentage of easily digestible proteins in the oil cake increases.

The use of a microwave installation for pre-sowing seed treatment increases the oilseeds yield by 10-15%, which provides an additional economic impact. Net present value for 3 years will amount to 715 thousand rubles; the payback period of the installation is within 1-2 years.
References

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