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TECHNOLOGICAL SCHEMES OF OILSEEDS PROCESSING

ТЕХНОЛОГІЧНІ СХЕМИ ПЕРЕРОБКИ ОЛІЙНИХ КУЛЬТУР

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Abstract. *The article provides a detailed review of technologies and techniques of oilseeds extraction. The principal structural scheme of oilseeds processing is developed.*

The main attention is paid to the waste-free oil and fat complex, from the improvement of pre-press preparation of seeds to the extraction of meals with the output to almost complete extraction of the valuable component using solvents.

Also, the oil and fat industry has undergone the most effective rate of development due to the intensification of extraction processes by the influence of various physical and mechanical factors. One of such factors is the influence of microwave field on the extraction process.

The article presents foreign and domestic studies on the effect of electromagnetic field on the extraction of valuable components in the food industry.

Key words: *extraction, microwave exposure, electromagnetic field, power, hydraulic module, solvent, pressing, technological scheme, oil and fat industry, soybean, rapeseed.*

Introduction.

The oil and fat industry in our country occupies a leading place in the agro-industrial complex, which is associated with the widespread introduction of scientific and technological achievements in the food industry, comprehensive intensification of production and high demand of the world market.

The production of vegetable oils is one of the leading branches of the food industry of the country. Its main products are vegetable oils - edible and technical. Edible vegetable oils, along with other products, form the basis of rational human nutrition. They are used for food both in pure (unchanged) form and in the form of processed products: margarine, cooking fat, mayonnaise and other products.

Technical oils are used for the preparation of soaps and detergents - household and technical, as well as oxidized oils used for the production of drying oils, varnishes, paints and biodiesel fuel. Some types of vegetable oils are used for the preparation of lubricants for special purposes, solvents for medicines, in the production of cosmetic products.

Wastes of vegetable oils production are of great economic value. After oil extraction from seeds - meal - is used as a concentrated feed for livestock, as a raw material for the preparation of food protein and other products.

Main text.

Seed hulls - husk, husk - are raw materials for hydrolysis production, the products of which serve as a source for obtaining various chemical products, as well as roughage for livestock.

The production of vegetable oils has been known since ancient times. Perhaps for the first time man began to use fruits and seeds of plants, which contain a lot of easily separated oil, to obtain vegetable oils. Most likely, the first were olive and palm oils, which are easy to extract from fruits with very little external pressure. With the development of technical capabilities, people began to extract oil from fruits and seeds, which are composed of strong plant tissues and contain relatively small amounts of oil.

The crushed seeds were usually pre-heated before pressing the oil, as heating contributed to a more complete and rapid separation of the oil. This is how the press method of vegetable oil production was formed, the basic sequence of technological operations of which: cleaning seeds from impurities, separation of shells, crushing the kernel and seeds, heat (moisture-heat) treatment, pressing - remains virtually unchanged for centuries.

The extraction method of obtaining vegetable oils is the most effective. It provides almost complete extraction of oil (oil residue in the skimmed material is less than 1%). This makes it possible to extract oil even from low-oil materials that are inaccessible to the most advanced presses.

For a long time, the extraction oil due to the imperfection of the solvents used and technological equipment was worse in quality than the pressed oil. This led to the creation of technological schemes of double extraction of oil, which included the extraction of the main part of the oil from the seeds by pre-pressing, and then extraction of the remaining oil from the pressed material. Pre-pressing of the oil allowed to improve the quality of the main part of the oil obtained and, in addition, to intensify the work of the extraction equipment. Preliminary and final degreasing was used not only at extraction plants, but also at pressing plants, where the final pressing of oil was performed on presses that develop high pressure but have relatively low productivity.

To extract oil from oil raw materials in the world practice of vegetable oil production there are two fundamentally different methods:

- mechanical oil extraction - pressing;
- extraction of oil in the form of a solution in volatile organic solvents with subsequent removal of the latter from the solution - extraction.

In the technological schemes of oilseed processing into oil, there are preparatory, main, auxiliary and additional operations (Figure 1).

In some cases, which are determined mainly by the nature and quality of the processed oilseeds, various combinations of these methods are used.

The preparatory operations include seed cleaning from impurities, drying, kernel dehulling.

Technological schemes used both in Ukraine and abroad are shown in Figure 2 (hot pressing) and Figure 3 (cold single pressing).

According to the hot pressing technology, the process is carried out as follows. Pre-cleaned and dried seeds are poured into the receiving hopper 1 and transported by a screw conveyor 2 to the roller machine 3. Here the seeds are crushed, turning into a mint.

The resulting mint is fed by conveyor 2 to the three-part roaster 4, where it is heated. For heating the mint in the fryer is the furnace 10.

The heated peppermint is transported by a screw conveyor 2 to the final press 5.

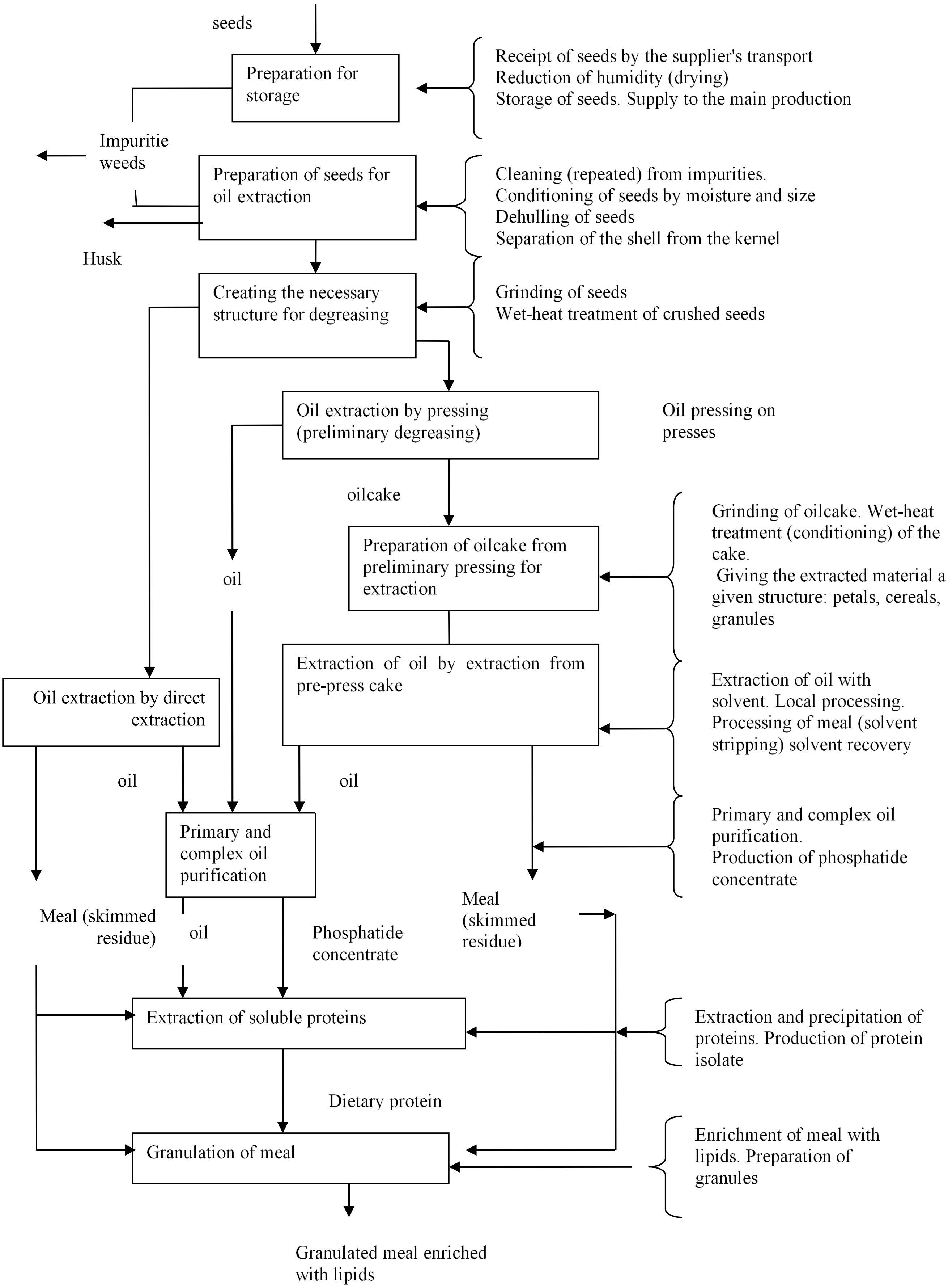

Figure 1 - Principal structural diagram of oilseeds processing

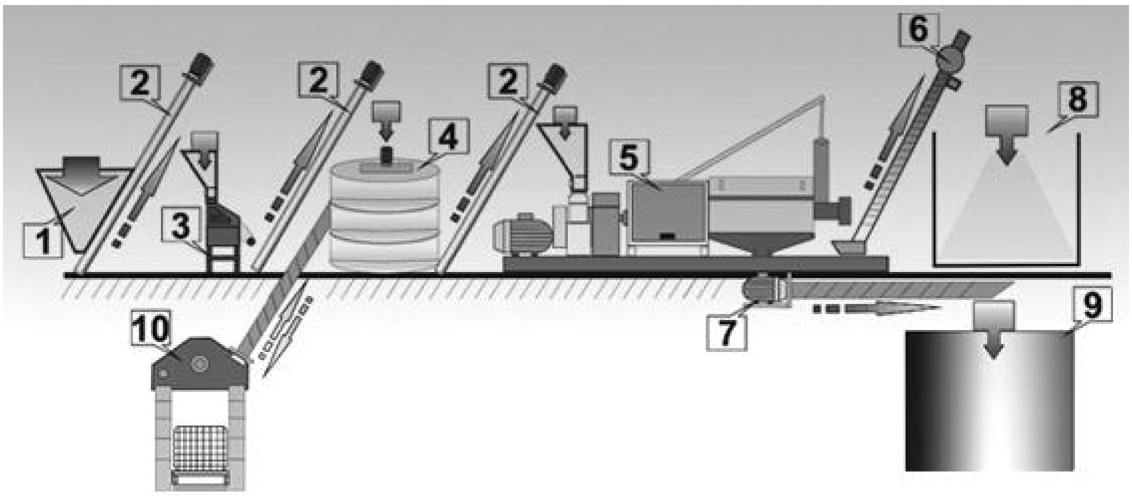

Figure 2 - Technological scheme of hot, one-time pressing:
1 - receiving hopper; 2 - conveyor; 3 - grinding-rolling unit; 4 - roaster 3 - vats; 5 - press; 6 - conveyor for cake selection; 7 - oil collector with pump; 8 - hopper for cake; 9 - oil storage tank; 10 - oven.

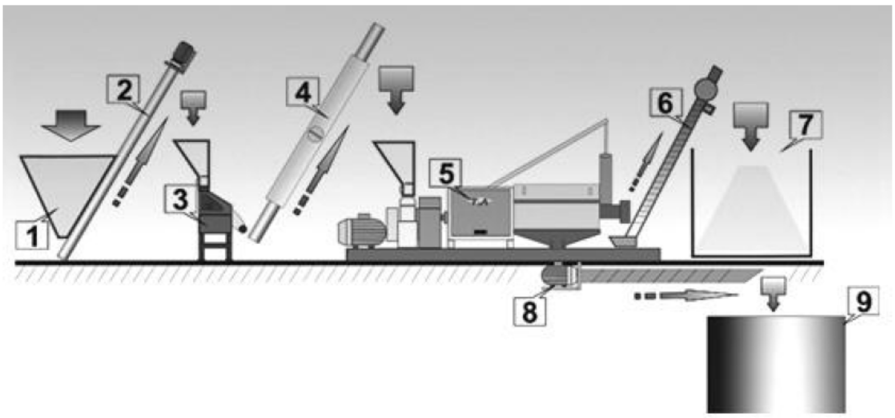

Figure 3 - Technological scheme of cold, one-time pressing:
1 - receiving hopper; 2 - conveyor; 3 - grinding-rolling unit; 4 - heated conveyor; 5 - press; 6 - conveyor for cake selection; 7 - cake hopper; 8 - oil collector with pump; 9 - oil storage tank.

The resulting oil passes through the gaps in the zeer cylinder, is collected on a pallet and drained into the oil collector 7, from where it is pumped by a pump to the oil storage tank 9. The cake coming out of the press is transported to a special hopper 8.

The operation of the line according to this scheme has a significant energy and metal consumption of production, in addition, the use of equipment for heating the oilcake leads to a decrease in oil quality and an increase in the cost of the final product.

The introduction of such a technological process in the conditions of farms with small volumes of raw materials production is impossible due to the branching of operations, which leads to high costs.

The technological scheme of vegetable oil production by the method of cold, one-time pressing differs from the previous one by the absence of a furnace for heat treatment of mint, which somewhat simplifies the technology, but has a sufficiently large number of units of complete equipment, which in turn leads to high metal consumption.

Also, during the analytical review of the literature, a generalized classification of methods that allow accelerating the extraction process was described, taking into account the fact that the efficiency of extraction largely depends on the method of preparing raw materials for the process. At this stage, intensification methods provide the necessary shape, size and dispersed composition of particles, increase the cell permeability of raw materials. To date, from the known studies, the use of microwave heating has allowed to intensify the process of heat treatment of raw materials and extraction of stable soluble substances. Positive results of using electromagnetic pulse radiation were obtained in the production of food dyes from beets, fruit and berry raw materials, in the scheme of accelerated maturation of cognac alcohols, in the extraction of cedar oil from Siberian pine seeds, in laboratory conditions to accelerate the extraction of fungicides from wood materials in the production of soybean oil, in the extraction of oils from mint leaves, rosemary, tea tree, sandalwood and other plants, in the extraction of nicotine from tobacco raw materials [4-8].

The basis of the use of microwaves in the food industry is their ability to heat products. Here are the positive characteristics of microwave heating in comparison with traditional methods of food processing:

1) high process speed (thus, drying time is reduced by 10 ... 30 times);

2) short time to enter the mode (does not exceed 1 ... 2 minutes);

3) the material is heated more uniformly (heat is distributed throughout the volume of the material, regardless of its thermal conductivity);

4) selectivity of the process: wet parts of the material warm up faster than dry, which is not typical of convection heating;

5) inertia-free heating and the possibility of full automation of the process (heating can be quickly started and also quickly stopped);

6) high efficiency of the process;

7) significant reduction of heat losses to the environment and reduction of its pollution (no need to use coolants);

8) reduction in the need for production space by 3 ... 5 times;

9) high bactericidal effect of microwave energy;

10) high nutritional value of products, preservation of vitamins;

11) reduction of service personnel by 10 ... 50%;

12) the possibility of obtaining finished products with new properties.

The use of MHP allows to significantly intensify the technological processes of food production, to implement waste-free and energy-saving technologies, improves the economic performance of production and the quality of the product.

Although there are a number of disadvantages that limit the use of processes in the microwave field in production lines:

- high initial cost;

- insufficiently high operating life of microwave generators (10 ... 15 thousand hours), while the share of the cost of generators in the total price of the installation is about 50%;

- lack of cheap enough containers made of dielectric materials with high temperature resistance;
- highly qualified personnel is required;
- lack of sufficient reliable material on the dielectric characteristics of food products and their absorption capabilities when absorbing electromagnetic energy;
- the need for sufficiently strict dosimetric control over the level of stray radiation;
- lack of sufficient material for economic justification of efficiency and evaluation of engineering in processes in the microwave field. It should be emphasized that the prospects of processes in the microwave field are enormous, especially since the experience of their practical use in food production is positive Technological processes of food production using pulsed electromagnetic energy, which makes it possible to significantly intensify the process, very often it is used in conjunction with other sources of heat - steam, hot air, which allows to obtain the most rational conditions for the process. In addition, the effect of the microwave field has proven to be an effective way of pretreatment, which allows to combine the increase of juice yield due to damage of protein-lipid cell membranes with the simultaneous inactivation of oxidative enzymes.

Microwave energy supply has unique abilities that create prerequisites for obtaining new technological effects - volumetric and selective nature of energy absorption. The selective nature of microwave energy absorption allows varying the moisture content and quality of water inside the product (free water, physically and chemically bound, etc.) to create the basis for the formation of various combinations of temperature, pressure and concentration fields inside the processed product.

The possibility of varying the pulse width of the energy supply gives an additional opportunity to achieve the destruction of cell membranes without a significant increase in temperature, and, consequently, to preserve the physiological active, nutrient and vitamin groups of the native product.

Due to the above features, the implementation of some processes achieves positive effects that are unlikely to be achieved with old technologies: intensification of freeze-drying processes, increasing the degree of extraction, drying of thermolabile products at low temperatures, etc.

Microwave process technologies are used for liquid and gas phases, both under normal and supercritical conditions. Some examples of the use of microwave processes in the liquid phase are: extraction of valuable oils, flavoring substances from plant raw materials, biphenols from animal tissues, polycyclic aromatic carbohydrates from polyurethane foams, which are used in the monitoring of air and various solids - soils, precipitation, etc. The second application of microwave processes is the extraction of dissolved organic matter from water.

In the UK, the use of microwave processes for sample preparation instead of the Soxhlet method has reduced the process time from 8...16 hours to 30 minutes, energy consumption by about 90%, while increasing the yield and purity of the extract. These properties not only reduce production costs, but are also considered more environmentally friendly. The method allows to determine more than 100 pollutants from various sources (soil, water, animal tissues, etc.) [14].

Microwave field processes are widespread in France, where they are used to determine the amount of fat in meat and dairy products [23]. In Canada, they are used to analyze the composition of river, lake and drinking water, polluted water of enterprises, due to the unique mechanism of energy transfer from substances that strongly absorb microwaves to water. A comparative analysis of the performance of conventional supercritical CO_2 extraction and liquid CO_2 extraction using microwave energy was carried out. The experimental results were similar, but in the second case there was no need for high pressure, which significantly reduces the capital cost of the equipment and reduces its metal consumption [2].

Scientists of the Technological University of Malaysia [14] considered the problem of using microwave extraction to obtain valuable vegetable oils from tea tree leaves, rosemary and other plant materials. Ethanol was used as an extractant for cineole, pinene and terpenoids. Gas chromatography was used to analyze the final solution, and an electron microscope was used to study the morphological structure of the cells. It was found that the yield of soluble substances was higher the higher was the dose of electromagnetic pulse radiation (1 dose is equal to 750 W for 60 seconds). To study the nature of the effect of the microwave field on the cells of plant material, photos of tea tree leaves before and after extraction, taken on an electron microscope, were compared. In the photo, there are noticeably fewer cells that include oils, the texture of the leaves looks deformed compared to the leaves that were not exposed to electrophysical influence [23].

The dissertation work of S. Armstrong presents the results of studies of microwave extraction of fungicides (substances with antifungal properties) from wood in order to prepare samples for laboratory analysis. The experiments showed that the longer the extraction time, the higher the yield of the final product. Optimal conditions for fungicide extraction: power - 90 W, time - 15 minutes. High power can lead to overheating and destruction of substances.

It was found that important components do not degrade under the influence of microwave energy. In order to understand the mechanism of microwave energy effect during extraction, two wood samples (with and without field exposure) were studied under a microscope. As a result, the following process mechanism was proposed. The capillaries of the tree are cylindrical, hollow in the middle, passing through themselves water with nutrients along the tree. Capillaries hold a large amount of water and under the influence of microwave energy can overheat, because the solution can not give off heat as fast as it absorbs. Microwaves interact with the solution and free water molecules, resulting in localized overheating. As a result, there is a heterogeneous temperature increase to the boiling point of water, and sometimes - higher. Consequently, the pressure in the middle of the capillaries increases, the walls of the capillaries can not withstand and collapse, allowing substances to freely escape into the extractant. Photographs of samples confirm this theory: capillary ruptures are visible on the image of the sample after microwave extraction.

The dissertation of V.G. Terziev [15] considers the possibility of improper use of PMWP in the production of spirits. Experiments on the extraction of oak wood with water in the boiling mode showed that the processes in the microwave field achieved a concentration of 1.5%, which is 5 times higher than with conventional electric heating. This discrepancy is explained by the effect of barodiffusion.

All of the above shows that the use of microwave processes for the extraction of plant raw materials requires less time for the process itself. At the same time, the yield and quality of the resulting product increases with less energy consumption.

In addition to the above positive qualities, extraction of plant material by means of microwave field does not require high pressure, has a selective extraction ability, does not require serious capital investments, does not require preliminary drying of the material, however, this technique requires accurate determination of the parameters of the microwave field, for which the generator must be designed so that the most important parameters of the process can be easily controlled. The speed and the possibilities of variation of this technology open up great opportunities for further activities.

Intensification of the process of extraction of target components from plant raw materials.

As a rule, the latest technologies arise following the formation of new requirements for product quality. Currently, the transition from quantitative to qualitative indicators is primarily related to the food industry.

Recently, attention to the development of modern technological processes, including the extraction process, has increased, as evidenced by a large number of scientific works in this area.

The greatest opportunity to intensify the extraction process is associated with the effect on the mass transfer coefficient, which depends on the hydrodynamics of the process, that is, on the speed of relative motion of the solid phase. This speed is also called the flow velocity. With an increase in the speed of the extractant relative to the raw material particles, the molecular transfer mechanism changes to convective and sharply reduces the size of the diffusion boundary layer. The choice of optimal hydrodynamic conditions makes it possible to replace expensive extractants with more affordable ones and, of course, reduce the costs associated with the grinding of raw materials.

When studying the effect of electromagnetic field on the extraction of oil from rapeseed and soybean, the results of significant intensification of the process were obtained. They showed that the yield of the target component during the intensification of the electromagnetic field is on average 30% higher than the extraction by the traditional method of infusion for a long time, and the time saving was 97%. Thus, in the study by the infusion method, the extraction lasted 5 hours, and when intensified by an electromagnetic field - 10 minutes with a difference in oil concentration up to 40% [12,15,16].

In our study, we used experimental stands №1 and №2 (Figures 4,5). The main elements of bench №1 were a chamber, which, thanks to the magnetron, created a microwave field, as well as a container in which the extraction process was carried out.

The stand provided regulation of the microwave field power. The principle of operation of the experimental stand is as follows: in a container with the product 3, the extraction process takes place under the influence of a microwave field in chamber 1. The extractant vapor enters the reflux condenser 2, condenses and flows back into the reaction vessel with the sample and solvent.

The range of experimental studies on the installation №1 is shown in Table 1.

The main factors affecting the extraction process are the size of the raw material fractions (d, mm), the presence and power (N, W) of the pulsed electromagnetic field (PEM field), the hydraulic module of the extract (ξ), temperature (t, ºC), extraction time (τ, s), solvents: alcohol C_2H_5OH, hexane C_6H_{14}.

Figure 4 - Stand for oil extraction №1:
1 - microwave chamber; 2 - reverse water cooler; 3 - container with the product.

Seeds	Type of raw material	Fraction	Hydromodule	Temperature, ºC	Solvent	Pulsed field effect	Power, W	Research time
1.Winter rape varieties "Champion"	Grain	0.5 mm - whole grain	1:3	From 12ºC - to the boiling point of the solvent	Alcohol and hexane	In the field and without field	127 W, 255 W, 425 W	From 5 min. to 24 hours.
	Oilcake	0.5 mm - 7 mm	1:3, 1:5, 1:10, 1:20					
2. Soybean variety "Vinnychanka"	Grain	0.5 mm - whole grain	1:3					
	Oil cake	0.5 mm - 7 mm	1:3, 1:5, 1:10, 1:20					

The principle of operation of the unit №2 (Figure 5): seeds of the studied oil-containing crops of rapeseed and soybean are fed into the fitting with a container for filling with solid phase 1, the solvent enters the extraction tank 4 through the fitting with a container for filling with solvent 2. The solvent condenses in the reflux condenser 3. Extraction intensification takes place in the electromagnetic intensifier 5.

During the study, the temperature of the product at the inlet 7 and at the outlet 8 of the microwave intensifier, as well as the temperature of the intermediate coolant 6, were measured using sensors.

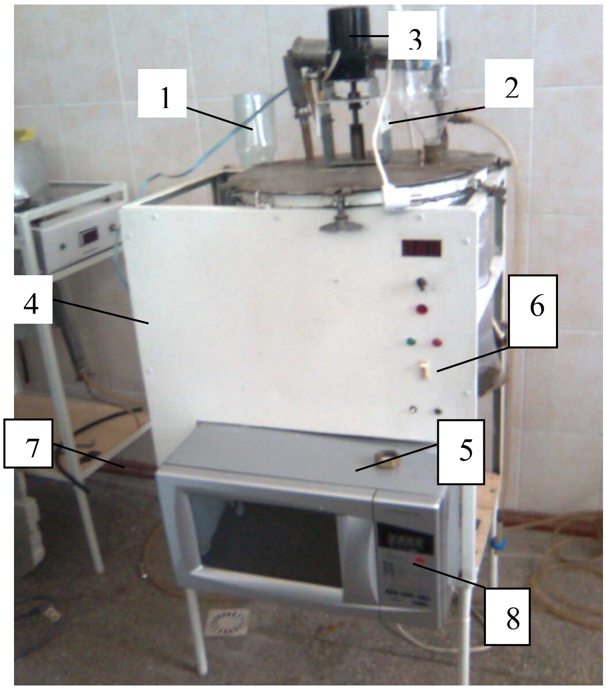

Figure 5. Extractor with microwave intensifier (MHI):
1 - fitting with a container for filling the extractor with a solvent; 2 - fitting with a container for filling the reaction volume with a solid phase; 3 - reflux cooler; 4 - extractor; 5 - electromagnetic intensifier; 6 - sensor for measuring the temperature of the intermediate coolant; 7 - sensor for measuring the temperature of the product at the inlet to the microwave; 8 - sensor for measuring the temperature of the product at the outlet of the microwave.

Characteristics of the experimental setup №2 for research (Table 2).

Table 2 - Characteristics of the extractor with microwave intensifier (MHI)

Installation characteristics	Quantity
1	2
volume of solvent (V)	0,008-0,015 m^3
mass of oil-containing rapeseed (Mn_r)	2-5 kg
mass of oil-containing soybean seeds (Mn_s)	2-5 kg
extraction time (τ)	15-32 min.
mass of rapeseed oil yield (Mo_r)	0,83-2,10 kg
soybean oil yield (Mo_r)	0,40-1,00 kg
MHP power (N)	0,8-1,2 kW/kg

The temperature of the intermediate coolant sensors located at the inlet and outlet of the microwave intensifier was measured at intervals of 2 minutes (Figure 6).

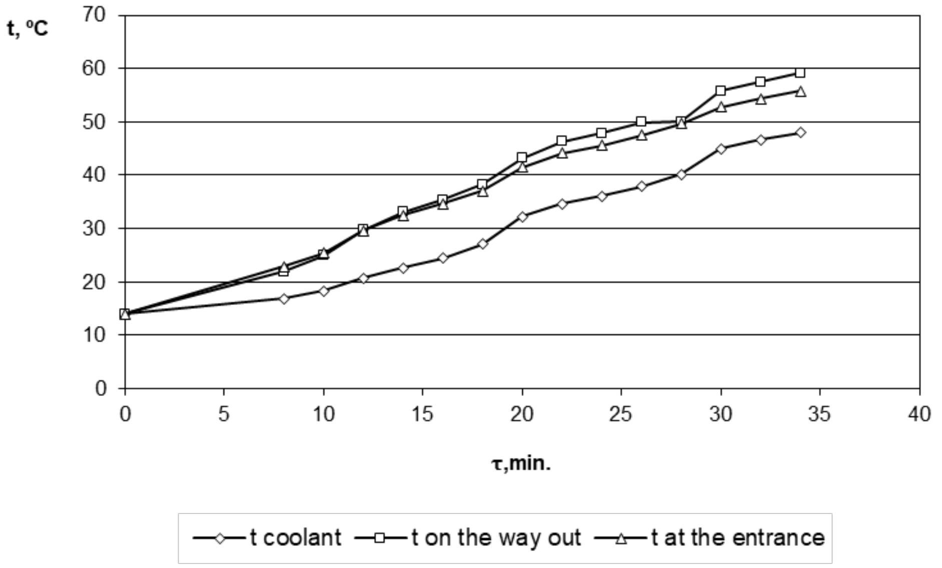

Figure 6 - Dependence of temperature on time in the process of extraction of rapeseed and soybean with ethanol in the extractor with MX intensifier.

As can be seen from the figure, the temperature of the micelle at the outlet of the MHI is the highest and during the study its maximum value was 59° C, at the inlet the maximum temperature was 56° C, and the temperature of the intermediate coolant was no more than 48° C at the end of the study.

During the extraction, samples were taken every 7 minutes to determine the concentration of mesta (Figure 7).

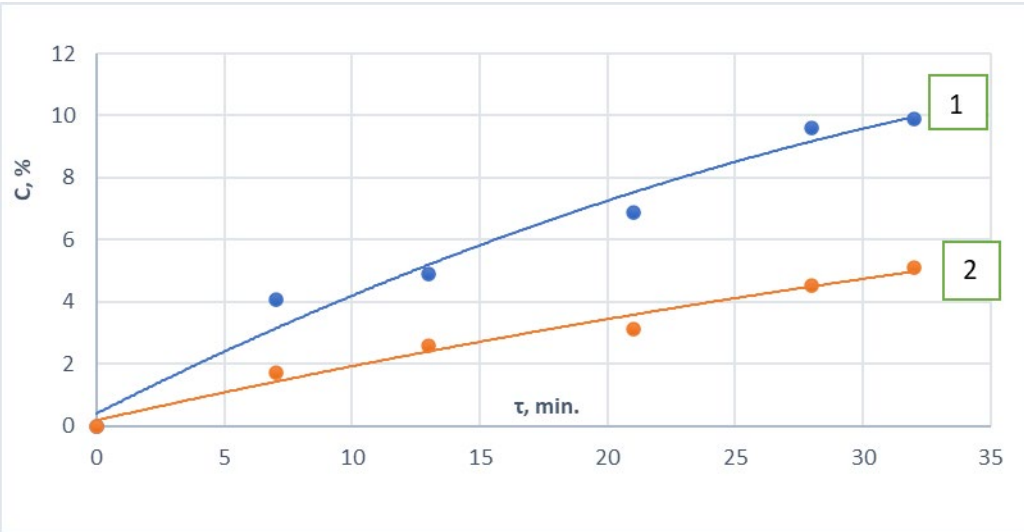

Figure 7 - Dependence of concentration on time in the process of extraction of rapeseed and soybean oil with alcohol in a microwave intensifier:
1) rapeseed+alcohol, 0.5-1 mm whole seed, 1:4, 800 W; 2) soy + alcohol, 0.5-1 mm whole seed, 1:4, 800 W.

For the study, rapeseed and soybean seeds crushed to a fraction of 0.5-1 mm were used as the most effective in extraction. The ratio of solid and liquid phases is 1:4. The microwave field power is 800 W.

An important indicator of the obtained samples of rapeseed and soybean oil is their chemical composition. The samples were examined in the laboratory of PJSC "Vinnytsia Oil and Fat Plant". The samples fully met the requirements of "SSTU 4534:2006 Soybean oil. Technical specifications" and "SSTU 46.072:2005 Rapeseed oil. Technical conditions".

The effectiveness of the use of polar solvent ethyl alcohol for this process is confirmed by the results of gas-liquid chromatography, which show that under the action of an electromagnetic field, this solvent intensifies the release of biologically active substances, in particular tocopherols $C_{29}H_{50}O_2$, from rapeseed and soybean seeds in addition to fatty acids. The content of tocopherols in the studied samples of oils obtained using a microwave intensifier is on average 2 times higher than in oils obtained by the traditional method.

In the scientific and technical literature devoted to the extraction of oils with hexane and ethyl alcohol solvents from soybean and rapeseed seeds under the action of a microwave field, there are practically no data on the mechanism of the process, phase equilibria, kinetics of mass transfer.

The use of the method of dimensionality analysis, obtaining the parameters of the combined extraction process was used in this work to process the experimental data and derive the criterion equation from the classical similarity numbers, taking into account the values of the parameters to get to the calculation of the extraction apparatus:

$$Sh = A \cdot Sc^{o} \cdot \varsigma^{\pi} \cdot Bu^{\sigma} \ , \qquad (1)$$

where A, o, π, σ are dimensionless constants;

Sc - Schmidt number, which shows the ratio of the amount of flow movement to the diffusion flow;

ζ - hydromodulus;

Bu - Bourdeau number, the number of energy action.

Constants A, o, π, σ of equation 1 were determined experimentally.

The constant o for the Sc number was taken equal to 0.33 as the influence of the Sc number in traditional mass transfer problems is usually established.

For the dimensionless complex of the solid-liquid phase ratio, the constant π was determined from the graphical dependences (Figures 8-9) of the hydromodule on the complex Z for the conditions "rapeseed-alcohol", "rapeseed-hexane", "soybean-alcohol", "soybean-hexane".

$$Z=Sh/Sc^{0,33} \qquad (2)$$

The coefficient σ for the energy number Bu was determined from the graphical dependence of the number Bu on the complex C (Figure 10).

$$C=Sh/(Sc^{0,33}-\zeta^{\pi}) \qquad (3)$$

The constant A was determined by the dependence:

$$A=C/Bu^{\sigma} \qquad (4)$$

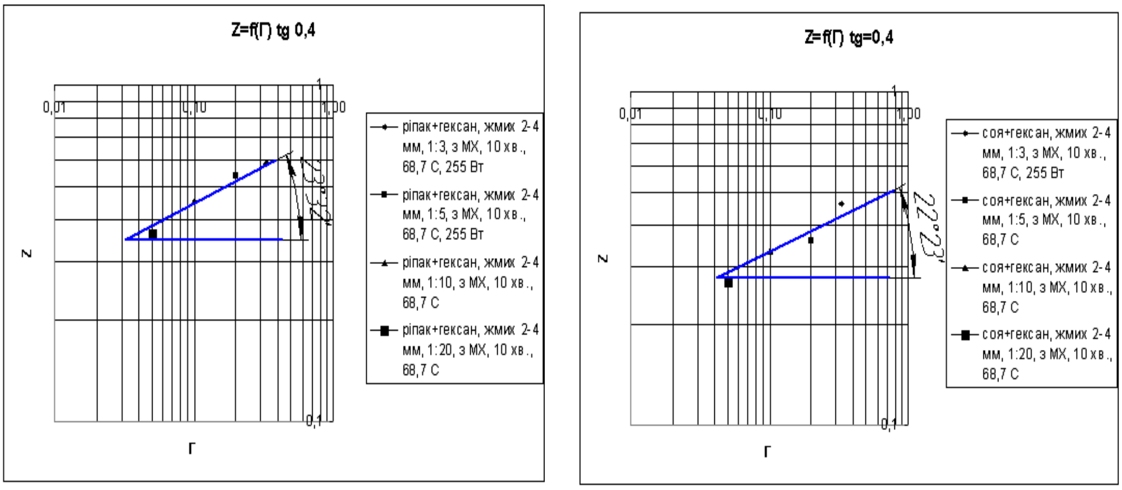

Figure 8 - Dependence of the dimensionless complex of the solid-liquid phase ratio on the complex Z for the conditions "rapeseed-hexane", "soybean-hexane".

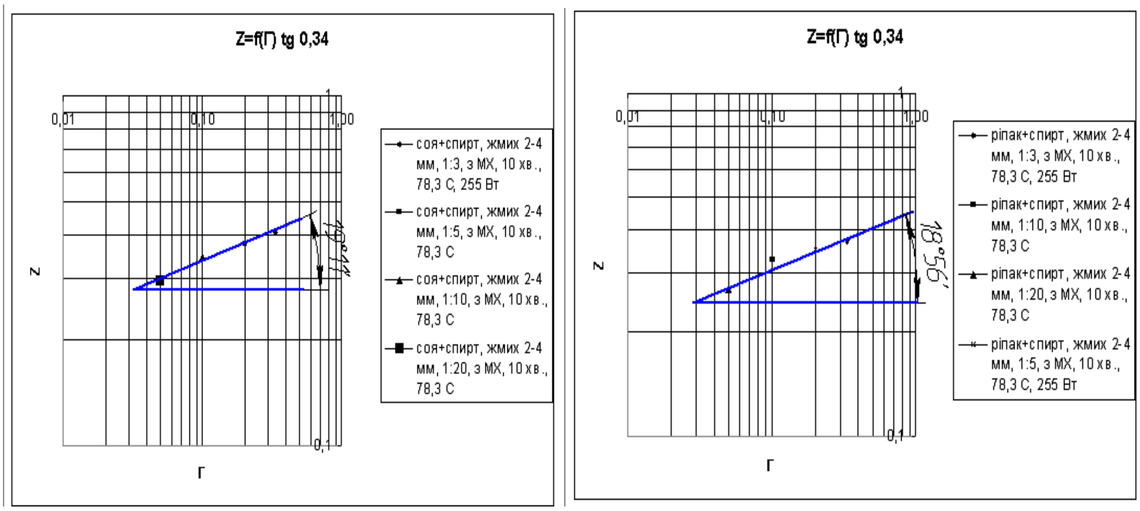

Figure 9 - Dependence of the dimensionless complex of the solid-liquid phase ratio on the complex Z for the conditions "soybean-alcohol", "rapeseed-alcohol".

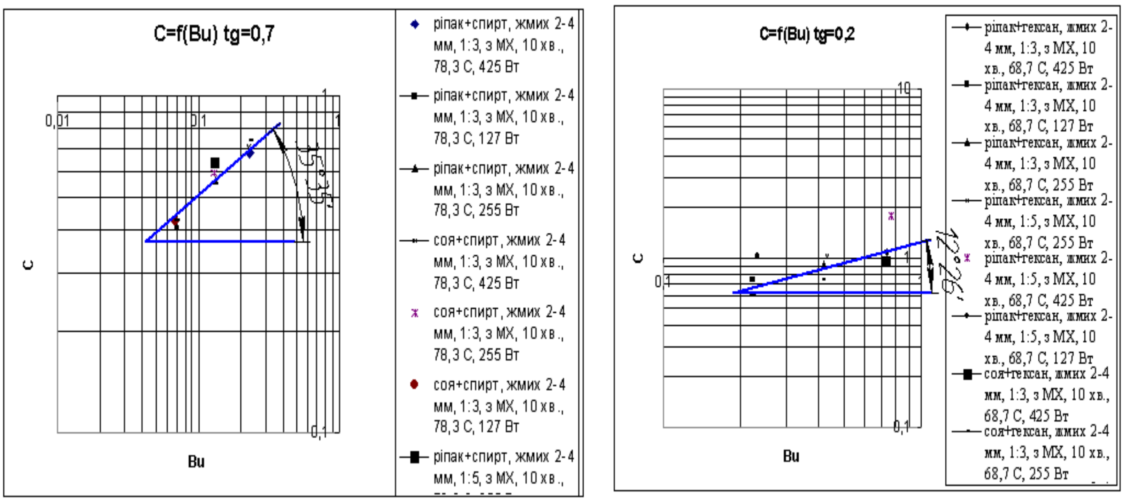

Figure 10 - Dependence of the energy action number Bu on the complex C for the conditions "soy-alcohol", "rapeseed-alcohol", "soy-hexane", "rapeseed-hexane".

The calculations of the values of mass transfer coefficients and similarity numbers for the conditions of studies of extraction of oil-containing rapeseed and soybean under the influence of the microwave field are presented.

As a result of the determined constants from the graphical dependences and on the basis of calculated and experimental data, the criterion equations for the conditions "rapeseed-alcohol", "rapeseed-hexane", "soybean-alcohol", "soybean-hexane" were obtained:

For rapeseed with alcohol: $Sh = 1{,}7 \cdot Sc^{0,33} \cdot \varsigma^{0,34} \cdot Bu^{0,7}$ (5)

For rapeseed with hexane: $Sh = 0{,}9 \cdot Sc^{0,33} \cdot \varsigma^{0,4} \cdot Bu^{0,2}$ (6)

For soybean seeds with alcohol: $Sh = 1{,}8 \cdot Sc^{0,33} \cdot \varsigma^{0,34} \cdot Bu^{0,7}$ (7)

For soybean seeds with hexane $Sh = 0{,}7 \cdot Sc^{0,33} \cdot \varsigma^{0,4} \cdot Bu^{0,2}$ (8)

Analysis of experimental and calculated data of dependences (5-8) showed that the calculation error is within 16% [1-27].

Conclusions.

Thus, the extraction of plant material by microwave field does not require high pressure, has a selective extraction ability, does not require serious capital investments, does not require preliminary drying of the material, however, this technique requires accurate determination of the parameters of the microwave field, for which the generator must be designed so that the most important parameters of the process can be easily controlled. The speed and possibilities of variation of this technology open up great opportunities for further activities.

The positive characteristics of microwave heating in comparison with traditional methods of product processing are: high speed of the process (for example, drying time is reduced by 10 ... 30 times); short time to enter the mode (does not exceed 1 ... 2 min.); the material is heated more homogeneously (heat is distributed throughout the volume of the material, regardless of its thermal conductivity); selectivity of the process: wet parts of the material are heated faster than dry, which is not typical of convection heating; inertia-free heating and the possibility of full automation of the process (heating can be quickly started and also quickly stopped); high efficiency of the process; significant reduction of heat losses to the environment and reduction of its pollution (no need to use coolants); reduction in the need for production space by 3 ... 5 times; high bactericidal effect of microwave energy; high nutritional value of products, preservation of vitamins; reduction of staff by 10 ... 50%; the ability to obtain finished products with new properties.

Although there are a number of disadvantages that limit the use of processes in the microwave field in technological lines: high initial cost; insufficiently high operating life of microwave generators (10 ... 15 thousand hours), while the share of the cost of generators in the total price of the installation is about 50%; lack of cheap enough containers made of dielectric materials with high temperature resistance; highly qualified personnel is required; lack of sufficient reliable material on the dielectric characteristics of food products.

References.

1. Abdurahimov, A. A., Kadrikov Yu. K., Serkaev K. P. Rafinaciiya hlopkovoj miscelly s ispolzovaniem processov gidratacii i elektromagnitnoj obrabotki.

Maslozhirovaya promyshlennost. 2014. № 4. S. 16-18.

2. Amer Ali, Rosli Mohd Yunus, Ramlan Abd. Aziz. Scrutiny of Microwave Essential Oil Extraction. Malaysia Technology University. 2003. 7 r.

3. Bandura V.M. Intensifikaciya masoperenesennya v ekstraguvanni roslinnih olij. Integrovani tehnologiyi ta energozberezhennya. Shokvartalnij naukovo-praktichnij zhurnal. Harkiv : NTU «HPI», 2013. №2. S.144-147.

4. Bujvol S.M., Burdo O. G.. Ispolzovanie energopodvoda pri ekstragirovanii. Tezisy dokladov VIII Mezhdunarodnoj nauchnoj konferencii studentov i aspirantov «Tehnika i tehnologiya pishevyh proizvodstv». Mogilev. 2012. Chast 2. S. 44.

5. Bujvol S.M.,. Burdo O.G, Bandura V. M. Doslidzhennya procesu ekstraguvannya iz vikoristannyam mikrohvilovogo polya. Harchova nauka i tehnologiya. Odesa. 2012. № 1 (18). S. 115 – 118.

6. Bujvol S.M., Burdo O. G. Ekstraguvannya oliyi iz netradicijnoyi sirovini. Tezi dopovidej vseuk.nauk.-prak. konf. molodih uchenih i studentiv «Aktualni problemi rozvitku harchovih virobnictv, gotelnogo, restorannogo gospodarstv i torgivli», 25 kvitnya, 2012. Harkiv: HDUHT. 2012. Ch. 2. S. 41.

7. Burdo O.G., Bujvol S.M.,. Bandura V. M. Kinetika ekstraguvannya oliyi iz roslinnoyi sirovini z vikoristannyam mikrohvilovogo polya. Zbirnik statej «Novitni tendenciyi u harchovih tehnologiyah ta yakist ta bezpechnist produktiv». Lviv. 2012. S. 29 – 33.

8. Burdo O.G., Bujvol S. M. Ekstraguvannya olij iz roslinnoyi sirovini z vikoristannyam mikrohvilovoyi tehnologiyi. Materiali mizhnarodnoyi naukovo-praktichnoyi konf. «Udoskonalennya procesiv i obladnannya – zaporuka innovacijnogo rozvitku harchovoyi promislovosti». Kiyiv: NUHT. 2012. S. 124 – 126.

9. Burdo, O., Bandura, V., Kolianovska, L., Dukulis, I. Experimental research of oil extraction from canola by using microwave technology (2017) Engineering for Rural Development, 16, pp. 296-302.

10. Byelinska, A. P. Tehnologiya kupazhovanoyi oliyi pidvishenoyi biologichnoyi cinnosti : dis. ... kand. tehn. nauk : 05.18.06. Nacionalnij tehnichnij universitet "Harkivskij politehnichnij institut". Harkiv, 2011. 230 s.

11. Cherstva A. O. Udoskonalennya tehnologiyi presovogo viluchennya ripakovoyi oliyi iz vikoristannyam fermentnih preparativ : avtoref. dis. … kand. tehn. nauk.: 05.18.12. K., 2018. – 18 s.

12. Dzhingilbaev S.S. Razvitie nauchnyh osnov intensifikacii processa otdeleniya rastitelnogo masla na ekstruderah: Avtoref. diss. d-ra. teh. nauk.: 05.18.12. RGP „NPC mehanizacii selskogo hozyajstva”. Almaty. 2007. 38 s.

13. Drukovanyi M.F., Bandura V.M., Kolianovska L.M., V.I. Palamarchuk. Udoskonalennia teplotekhnolohii pry vyrobnytstvi olii ta biodyzelnoho palnoho. Monohrafiia. Vinnytsia, RVV VNAU, 2014. 254 s.

14. Ihno N.P. O rentabelnosti glubokoj pererabotki semyan podsolnechnika. Olijno-zhirovij kompleks 2005. №2(9). S.48-49.

15. Hupe M. Effects of moisture content in cigar tobacco on nicotine extraction – similarity between Soxhlet and focused open-vessel microwave-assisted techniques. J. Cromatogr. 2003. 1011. № 1-2. R. 213-219.

16. Kinetika ta statika ekstraguvannya oliyi z vidhodiv harchovih virobnictv. Terziyev S.G. ta in. Odesa: ONAHT, 2012. Vip. 42. Tom. 1. S. 344-348.

17. Kolyanovska L., Palamarchuk I., Sukhenko Y., Mushtruk M., Sukhenko V., Vasuliev V., Semko T., Tyshchenko L., Popiel P., Mussabekova A., Bissarinov B.. Mathematical modeling of the extraction process of oilcontaining raw materials with pulsed intensification of heat of mass transfer. Proceedings of SPIE. 18th Conference on Optical Fibers and Their Applications, 2018, Naleczow, Poland. 15 March 2019.

18. Listopad V. L. Maslozhirovaya otrasl Ukrainy : vyzovy vremeni i strategicheskie prioritety. Maslozhirovoj kompleks. 2015. № 1(48). S. 19–23.

19. Mank V., Nosenko T., T. Voloshenko Investigation of antioxidant properties of rape pressing. Harchova nauka i tehnologiya. 2015. № 1 (30). P. 33-36.

20. Osadchuk P. I., Dudaryev I.I. Formuvannya tehnologiyi ochistki roslinnoyi oliyi v umovah minicehiv. Naukovi praci ONAHT. O., 2018. T. 82, vip. 1. S. 99-108.

21. Popov M. O. Osnovni napryamki energozberezhennya v olijno-zhirovij galuzi. Tehnichni nauki : stan, dosyagnennya i perspektivi rozvitku m'yasnoyi, oliyezhirovoyi ta molochnoyi galuzej. 2012. S. 98.

22. Semko T., Novgorodska N., Kolianovska L., Blaschuk V., Solomon A. Development of resource-saving technologies of cheeses Global Science and Innovation [Text] : materials of the VII International Scientific Conference, Chicago, March 23-24th, 2016 / publishing office Accent Graphics communications – Chicago – USA, 2016. – C. 208-212.

23. Shten O. Produkciya yaku vipuskaye Vinnickij olijnozhirovij kombinat, koristuyetsya nezminno visokim popitom u spozhivachiv. Harchova i pererobna promislovist. 1995. № 12. S. 10–11.

24. Sirohman I. V. Napryami pidvishennya stabilnosti roslinnih olij u tehnologichnih procesah i pid chas zberigannya. Visnik Lvivskogo torgovelno-ekonomichnogo universitetu : zb. nauk. pr. Ser. Tehnichni nauki. Lviv, 2016. S. 74-78.

25. Topilin G.Ye., Ked I.A. Ustanovka dlya dvohstupenevoyi ochistki roslinnoyi oliyi. Patent Ukrayini na vinahid (korisnu model) № 2008 04888, 15.04.2008.

26. Udoskonalennya teplotehnologiyi pri virobnictvi oliyi ta biodizelnogo palnogo. Monografiya. / Drukovanij M.F ta in. Vinnicya, RVV VNAU, 2014. 254 s.

27. Universalnyj sposob proizvodstva rastitelnyh masel. A.Shkato ta in. MOTROL Motoryzacja i Energetyka Rolnictwa, Lublin, 2008, 10V, 156-161.

28. Vlasenko I., Semko T. Olijno-zhirova galuz Ukrayini: vikliki ta potencial rozvitku. Tovari i rinki. 2019. № 3 (31). S. 50–59.

29. Vlasenko V.V., Bandura V.M., Kolyanovska L.M. Intensifikuvannya ekstraguvannya v tehnologiyi virobnictva roslinnih olij. Monografiya. Vinnicya, RVV VNAU, 2016. 203 s.

Анотація. *В статті проводиться детальний огляд технологій та технік екстрагування олійних культур. Розроблено принципову структурну схему переробки олійної сировини.*

Основну увагу приділено безвідходності олійно-жирового комплексу, від удосконалення допресової підготовки насіння і до проведення екстрагування шротів із виходом до майже *повного вилучення цінного компоненту за допомогою розчинників.*

Також найефективнішого темпу розвитку зазнала олійно-жирова галузь за рахунок інтенсифікування процесів вилучення шляхом впливу різноманітних фізичних та механічних факторів. Одним із таких факторів є вплив мікрохвильового поля на процес екстрагування.

В статті наводяться зарубіжні та вітчизняні дослідження із впливу електромагнітного поля на процеси вилучення цінних компонентів в харчовій промисловості.

Ключові слова: *екстрагування, мікрохвильовий вплив, електромагнітне поле, потужність, гідромодуль, розчинник, пресування, технологічна схема, олійно-жирова галузь, соя, ріпак.*

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