



PROSPECTS OF TECHNOLOGY FOR THE PRODUCTION OF NON-TRADITIONAL FUNCTIONAL OILS

<https://doi.org/10.70728/a.series.v08.i02.015>

Isroilova Shoirakhon Jamshidovna

*Food technology department, doctoral student,
Tashkent Institute of Chemical Technology,
sherliverpool.211@gmail.com*

Serkaev Kamar Pardayevich

*Professor of the Department of Food Technology, DSc,
Tashkent Institute of Chemical Technology
serkayev@mail.ru*

Khamidova Madina Olimjonovna

*V.V.b Associate Professor of the Department of Food Technology, PhD,
Tashkent Institute of Chemical Technology
madinakhamidova113@gmail.com*

Abstract. The study is to develop an improved hydrothermal treatment technology for oil-bearing materials and primary press cake to yield functional vegetable oils from non-traditional oilseeds (melon and watermelon seeds). Analytical evaluation of the crushed kernels, mash, oils, and press cakes was carried out according to the standardized methods, and the requirements of GOST, in parallel experiments with the statistical validation of the results. Optimal hydrothermal treatment prior to primary pressing was 80°C for 40–50 minutes. Treatment at 80 degrees for 50 minutes led to a significant increase in oil yield, to 26.2% for melon and 17.6% for watermelon mash, a 14.5% increase compared to the untreated samples. Additional conditioning of the primary press cake (moisture adjustment till 12%, 1200C steam treatment at 0.5 MPA for 30 minutes) before expelling enhanced oil recovery. The developed double-pressing technology guarantees oil extraction efficiency at maximum levels.

Key words: oilseeds, oil cake, functional oils, pressing, essential fatty acids w3 and w6, melon seeds, watermelon seeds.

Аннотация. Целью исследования является разработка усовершенствованной технологии гидротермальной обработки масличных материалов и первичного жмыха для получения функциональных растительных масел из нетрадиционных масличных культур (семян дыни и арбуза). Аналитическая оценка измельченных ядер, пюре,

масел и жмыхов проводилась в соответствии со стандартизированными методами и требованиями ГОСТа в ходе параллельных экспериментов со статистической проверкой результатов. Оптимальная гидротермальная обработка перед первичным прессованием составляла 80°C в течение 40-50 минут. Обработка при температуре 80 градусов в течение 50 минут привела к значительному увеличению выхода масла - до 26,2% для дыни и 17,6% для арбузного пюре, что на 14,5% больше по сравнению с необработанными образцами. Дополнительное кондиционирование первичного жмыха (доведение влажности до 12%, обработка паром при температуре 1200°C и давлении 0,5 МПа в течение 30 минут) перед отжимом позволяет повысить извлечение масла. Разработанная технология двойного прессования гарантирует максимальную эффективность извлечения масла.

Ключевые слова: масличные культуры, жмых, функциональные масла, отжим, незаменимые жирные кислоты w3 и w6, семена дыни, арбуза.

Annotatsiya. Mazkur tadqiqotning maqsadi noan’anaviy moyli xomashyo — qovun va tarvuz urug‘laridan funksional o‘simlik moylari olish uchun moyli material va birlamchi presslangan kunjara gidrotermik ishlov berishning takomillashtirilgan texnologiyasini ishlab chiqishdan iborat. Ezilgan yadro, mezga, olingan moy va kunjara namunalari amaldagi standart metodikalar hamda GOST talablari asosida tahlil qilindi, natijalar ishonchliligi parallel tajribalar va statistik baholash orqali ta’minlandi. Birlamchi presslashdan oldin 80°C haroratda 40–50 daqiqalik gidrotermik ishlov optimal deb topildi. 50 daqiqalik ishlov moy chiqishini sezilarli oshirdi: qovun mezasidan 26,2%, tarvuz mezasidan 17,6% moy olindi. Qayta namlash va 120°C bug‘ bilan ishlov berish (0,5 MPa, 30 daqqa) ekspellerlash samaradorligini oshirdi. Ishlab chiqilgan ikki bosqichli presslash texnologiyasi moy ajratib olish darajasini maksimal ta’minlaydi.

Kalit so‘zlar: moyli ekinlar, kunjara, funksional moylar, presslash, yog‘ kislotalari Omega-3 va Omega-6, qovun va tarvuz urug‘lari.

Introduction. As you know, vegetable oils have high biological value and are a source of essential polyunsaturated fatty acids, vitamins and trace elements. They are a structural part of all body tissues, have a beneficial effect on many of its systems and functions, and also contribute to proper metabolism. In this regard, vegetable oils are widely used in medicine, cosmetology and perfumery, the food industry and dietary nutrition. And such a wide use of them leads to the need to obtain environmentally friendly oils with the maximum content of biologically active substances. In this regard, an urgent task is to develop methods for deep processing of oil-containing raw materials to produce environmentally friendly fatty products. Deep (complex) processing implies the creation and application of technologies that allow the waste-free use of all components of raw materials and the production of functional products [1, pp.171-177]. This report presents the results of work on the development of technology for the production of functional oils from melon and watermelon seeds, which are rich in mono- and deunsaturated fatty acids.

Literature review. Typically making vegetable oil involves heating it for a time before pressing it. This process, which can take 20 to 50 minutes at a temperature of 100 to 120°C destroys some nutrients in the oilseed kernels. These nutrients include vitamin E and carotene.

- Vitamin E helps to slow down aging and can prevent cancer.
- Carotene, which is converted into vitamin A in the body is important for vision and growth.

When oilseed kernels are heated and pressed for a time unwanted substances can get into the oil. To remove these substances the oil needs to be refined and processed with chemicals. However this process can also destroy some of the remaining vitamins and proteins in the oil. As a result the oil may not stay fresh for long when it is stored.

Oil that is obtained by pressing is easier to digest and has more vitamins and good compounds compared to oil that is produced by hot pressing. This is especially true when compared to oil.

Some crops like amaranth have an oil content, usually not more than 13 to 14%. The main challenge in making oil from these crops is getting them ready for pressing. Most machines used for pressing oil are designed for crops that have an oil content of at least 15%. This makes it hard to use these machines for crops, with oil content.

The main reason is that pellet formation from press cake gets disrupted. This happens when the press cake is discharged through die openings in the working zone of the press. We know that for pellet formation the press cake needs to have at least 6-8% fat.

To ensure the cold-press oil press works steadily a new process was suggested. This process involves pressing oil raw materials with other oil-containing materials. The goal is to make sure the combined oil content is over 15%. When these materials are pressed together the oils. Provide enough fat for pellet formation. This helps the pellets come out through the die openings properly.

The oil content in the press cake needs to be right for pellet formation. This happens when the mixed raw materials have than 15% fat. This is also important for the press to work properly. Usually, a pre-treatment is done using steam or dry heat on oilseeds. Some methods use microwave pre-treatment to improve oil extraction and storage stability. This pre-treatment helps in improving oil extraction efficiency. It also helps in maintaining oil storage stability. Some studies have looked into microwave pre-treatment. These studies show that microwave pre-treatment can improve oil extraction efficiency.

The studies include:

- One study that found microwave pre-treatment to improve oil extraction efficiency
- Another study that looked at oil storage stability
- A study that found microwave pre-treatment to improve oil extraction efficiency and oil storage stability
- A study on oil extraction efficiency

- A study on oil storage stability
- A study that looked at microwave pre-treatment and its effects
- A study on the benefits of microwave pre-treatment
- A study, on microwave -treatment methods

As mentioned above, hydrothermal processing of seeds can cause favorable changes in physicochemical, functional, and sensory properties. Prior to assessing its impact on these properties, it is essential to examine the impact of hydrothermal processing on the key components of oil-bearing materials in order to acquire basic information for food processing, which can lead to enhanced quality and increased use of processed seeds as food materials. Nevertheless, there is limited information available on hydrothermal processing of seeds in low-moisture conditions, whereas the impact of hydrothermal processing of soybeans in high-moisture conditions, after sufficient water absorption, has been widely investigated [10, p.207-214; 13, p.1164-1171; 12, p.86-89].

Taking into account the importance of these topics, experimental work was carried out to provide an effective approach for oil extraction from melon and watermelon seeds, ensuring the production of oils and press cakes suitable for further food processing [11, p. 180].

Materials and methods

In the present work, dry melon and watermelon seeds were used as the subject of the research. The subject of the work was the process of oil extraction from the seeds of the melon and watermelon cucurbit plants using the method of double pressing combined with hydrothermal treatment and microwave irradiation. The analysis of the pressed oil was performed using the following methods:

The oil color was measured using a Lovibond colorimeter according to the O’zDSt 1199 standard [2, 11 p.].

The acid value of the oil was measured according to the O’zDSt 1203 standard using a 1% solution of phenolphthalein in alcohol as the indicator [3, 10 p.]. The method is based on the titration of the oil solution with an alkaline solution in the presence of phenolphthalein. A neutralized solution of ethanol and diethyl ether was used as the solvent.

3-5 grams of oil was weighed on the balance, diluted with 50 mL of the neutralized solution of diethyl ether and ethanol, and 3-5 drops of the 1% solution of phenolphthalein were added. The solution was titrated with 0.1 N alcoholic solution of potassium hydroxide from the burette with constant stirring until the solution remained pale pink for 30 seconds.

- Moisture and volatile matter content were determined according to O’zDSt 1193 [4, 11 p.].

- The oxidation degree of oils was evaluated by peroxide value using the iodometric method according to O’zDSt 1200 [5, 152 p.; 6, 9 p.].

- Oil content in processed materials was determined by exhaustive extraction using a Naab apparatus [7, 661 p.].

- Moisture content of oil-bearing materials and miscella concentration were analyzed by the gravimetric method [8, 18 p.].

- Crude protein content and its soluble fractions in press cake were determined by the Kjeldahl macro method [9, 302 p.].

Results

The objects of our research were selected based on the functionality of their composition, i.e. they are rich in mono and disaturated fatty acids, the so-called w3 and w6 fatty acids. The content of linolenic acid (w3) in the oil indicates its biological value, since this acid is essential. In addition, the vegetable oils studied by us from oil sources are rich in fat-soluble vitamins and biologically active substances.

In the table. 1 and 2 are the general information of the above seeds.

Table 1. Physical parameters of the studied oilseeds

Type of oilseed raw materials	Humidity, %	Absolute weight, gr	Weight of 1 m3 of seeds, kg	Borehole, %
Melon	5,7-7,2	3,9-7,8	590-630	27-35
Watermelon	6,5-6,9	5,4-6,9	770-810	21-24

Table 2. Chemical composition of the studied oilseeds

Type of oilseed raw materials	Lipids/%	Squirrels/%	Fiber/%	Ash content/%
Melon	35,2-43,1	23,7-25,6	12,1-15,4	4,2-4,7
Watermelon	23,7-25,9	19,8-22,3	16,7-19,2	5,7-11,4

In the experiments, crushed material from the studied samples was used. The crushed seeds were moistened until the humidity reached 11% with water, the temperature of which was 80C. Then the moistened material was subjected to heat treatment at a temperature of 100C to obtain a pulp with a humidity of 3% to 9% and subjected to pressing.

The results are shown in Fig. 1.

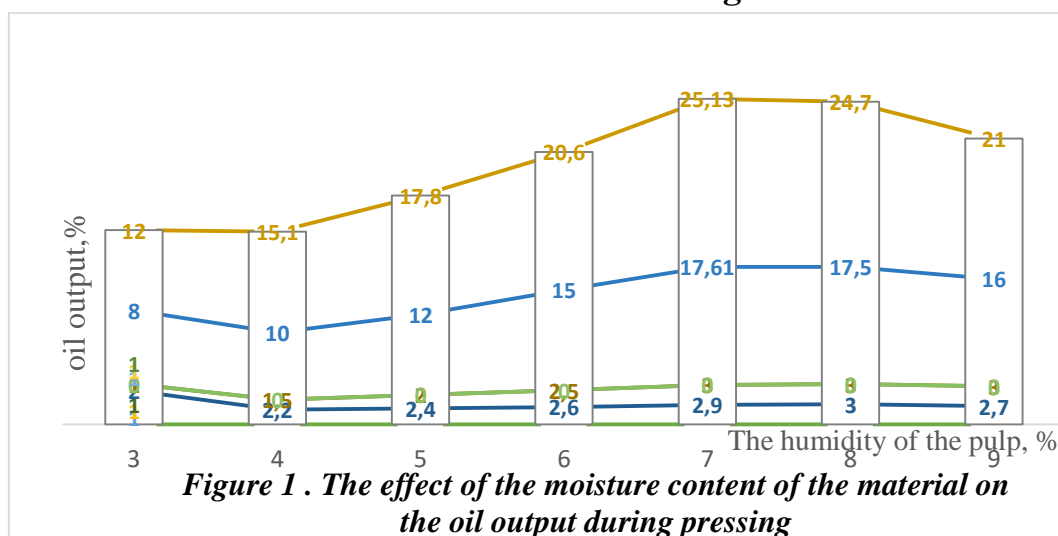


Figure 1 . The effect of the moisture content of the material on the oil output during pressing

As can be seen from Fig. 1, the highest oil yield is observed at a humidity of 7 ± 0.5%. To determine the optimal humidity of hydrothermal treatment, the crushed seeds

were moistened until the humidity reached 11% with water, the temperature of which was 80C. Then the moistened material was subjected to heat treatment at a temperature of 80C for 60 minutes and a decrease in humidity was observed in the time interval every 10 minutes. The optimal duration of heat treatment is considered, at which the moisture content of the material is $7 \pm 0.5\%$. The effect of the duration of heat treatment on reducing the moisture content of the pulp is shown in Fig. 2.

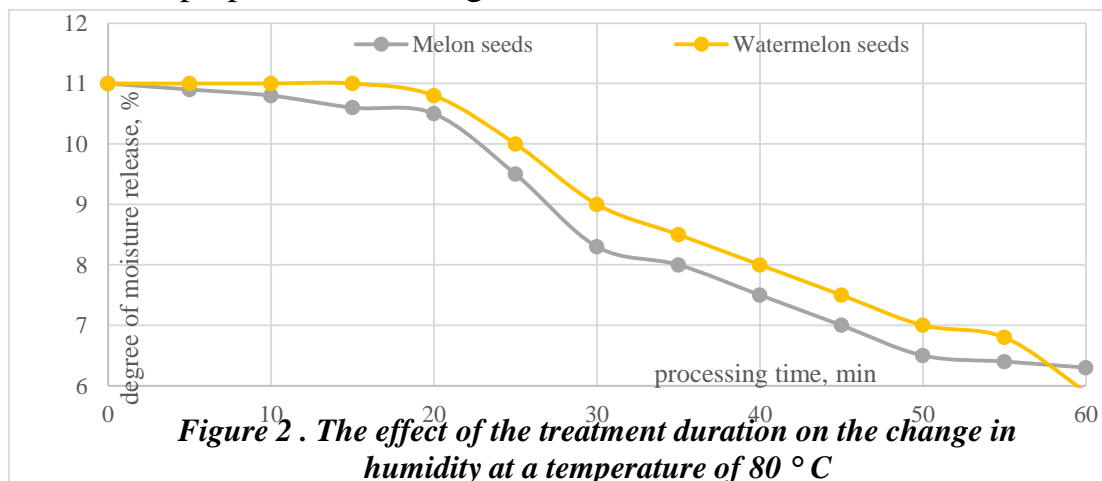


Figure 2. The effect of the treatment duration on the change in humidity at a temperature of 80 °C

As can be seen from Fig. 2, crushed materials from melon and watermelon seeds release moisture more slowly. For example, when the duration of heat treatment is up to 25 minutes, the above materials almost do not lose moisture.

In the interval of 30-50 minutes, the moisture content decreases rapidly and in the interval of 40-50 minutes, the humidity decreases to 7%. This is due to the structure of the material. The higher the oil content, the lower the content of the protein and structural part, which prevents the evaporation of moisture and vice versa.

Based on the data obtained, it can be concluded that the optimal interval of heat treatment of the studied samples of raw materials at a temperature of 80C is 40-50 min.

To verify the reliability of the data obtained, at the next stage of the experiments, the oil yield from the selected research objects was determined.

In order to obtain comparative results, seeds from one batch were used in all further experiments, i.e. one sample from all the objects of study. Seed quality indicators are given in table 3.

Table 3. The main qualitative indicators of the seeds used

Type of seeds	Oil content, %	Humidity, %	Soreness, %	Acid number of oil, mg KOH/g
Melon	35,3	7,2	2,1	0,18
Watermelon	23,9	6,8	1,9	0,98

In experiments, first the seeds were crushed in a hammer crusher to 60% of the passage through a 1 mm sieve and moistened with water at a temperature of 80C, and bringing the moisture content of the material to 11%. The moistened seeds were treated at a

temperature of 80C for 40-50 minutes. To extract the oil, a ZX-130 press was used in the pre-pressing mode. The results obtained are shown in Table 4.

Table 4. Results of pre-pressing of heat-treated and untreated pulp

Indicators	Type of processing			
	Melon		Watermelon	
	Without heat treatment	80 °C	Without heat treatment	80 °C
Oil output, %	24,3	26,2	3,1	17,6
Pomace output, %	74,8	69,3	95,8	78,3
Moisture loss, %	0,9	4,5	1,1	4,1
Balance:	100	100	100	100

As can be seen from the data given in Table 4, pressing mint from melon produced 24.3% and watermelon 3.1% of crude oil. The low yield of oil from watermelon mint is due to the rigidity of the husk, as a result of which moisture penetrates the material more slowly and reduces the processing effect.

When the mint was moistened and treated at a temperature of 80C for 50 min. the increase in oil yield is significant, so 26.2% of melon pulp and 17.6% of watermelon oil were obtained. When pressing pulp obtained from watermelon seeds, the oil yield from hydrothermally treated material is 14.5% higher compared to untreated.

The above data indicate that hydrothermal treatment of the studied samples of unconventional oilseeds under gentle regimes (no more than 80C) increases the yield of prepress oil.

In experiments, the optimal temperature of hydrothermal treatment of the moistened material was determined before the final oil extraction. To determine the optimal processing temperature, the crushed cake was first moistened to 12% with steam at a temperature of 120C and a pressure of 0.5 MPa. Then, the moistened material was thermally treated at different temperatures (from 100 to 130C) for 60 minutes. The results of the experiments are shown in Table. 5 and fig. 3.

Table 5. The effect of the temperature of the frying process on the evaporation of moisture from the moistened material (crushed pomace)

Heat treatment temperature, °C	Processing time, min					
	10	20	30	40	50	60
	Evaporation of moisture and volatile substances, %					
from melon seeds						
100	1,47	1,78	2,21	2,78	3,22	3,65
110	1,66	2,11	3,17	3,44	3,99	4,24
120	1,90	2,34	5,11	5,54	5,97	6,29

130	2,60	3,03	5,24	6,02	6,34	6,99
from watermelon seeds						
100	1,12	1,54	2,05	2,57	3,29	4,18
110	1,31	1,78	3,11	3,38	4,03	4,78
120	1,45	2,02	4,67	5,07	5,87	6,25
130	1,57	2,23	4,97	5,41	6,12	6,78

As can be seen from the data given in Table 5, frying of the crushed and moistened material of the studied samples at a temperature above 100C provides intensive evaporation of moisture in all time intervals. Based on the fact that the moisture content of the material within $7 \pm 0.5\%$ of moisture is required for pressing the pulp, the optimal time interval and temperature are considered to provide the required value. After studying the data in Table 5, we came to the conclusion that the optimal roasting temperature, before the final pressing of the studied samples, is 120C with a process duration of 30 minutes, because in this time interval, the residual moisture of the seeds decreases to $7.0 \pm 0.5\%$ in almost all the studied samples. Changes in the intensity of moisture evaporation, depending on the duration of the process at a temperature of 120C, are shown in Fig. 3.

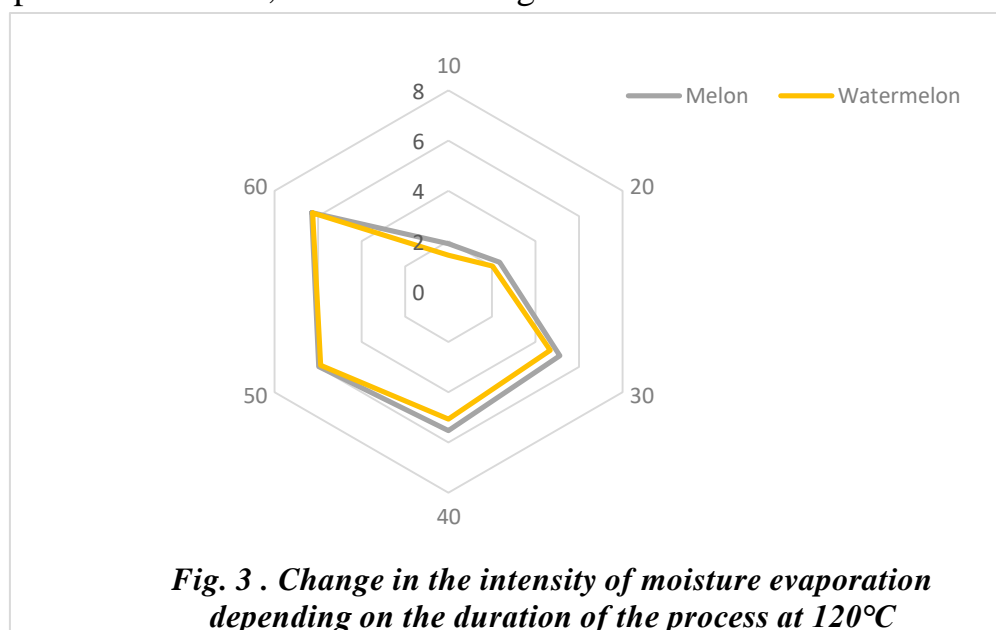


Fig. 3 . Change in the intensity of moisture evaporation depending on the duration of the process at 120°C

As can be seen from Fig. 3, the evaporation rate increases from 20 min to 40 min and continues almost uniformly up to 50 min. In the interval from 50 to 60 minutes, the evaporation intensity decreases. It can be seen from the constructed diagram that the processing time of 30 minutes is optimal. The effect of the duration of heat treatment at 120C on the degree of oil extraction during final pressing is shown in Fig. 4.

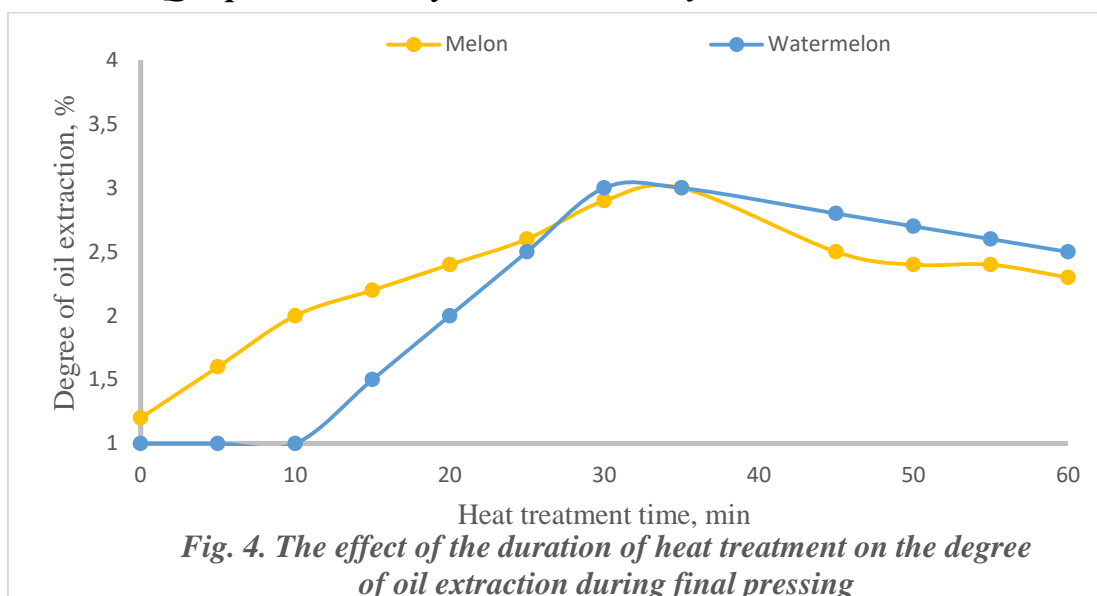


Fig. 4. The effect of the duration of heat treatment on the degree of oil extraction during final pressing

It can be seen from Fig. 4 that during heat treatment, with a decrease in humidity, the yield of expeller oil increases in the time interval from 10 to 30 minutes, and almost all samples begin to decrease after this interval, which is associated with overcooking the pulp. To confirm the obtained results of the study of the effect of hydrothermal processing of mint, before pre-pressing, and crushed cake, before final pressing, a series of experiments were conducted, the results of which were investigated in a complex. In control experiments, the studied seeds were first processed according to a well-known technology, i.e. the crushed seeds were first moistened to 8-9%, thermally treated at a temperature of 70C for 30 minutes and pre-pressed. At the second stage, the oil was extracted by expelling the primary cake, without humidification and heat treatment.

In experimental experiments, first seeds (melon, watermelon) were crushed in a hammer crusher up to 60% of the passage through a 1 mm sieve, moistened with water at a temperature of 80C, bringing the moisture content of the material to 11%, regardless of the type of oilseed raw materials. Then it was processed at a temperature of 80C for 50 minutes, based on the results of preliminary experiments. The heat-treated pulp with a humidity of $7.0 \pm 0.5\%$ was pressed in the pre-pressing mode. Part of the resulting oil and cake was sent to the laboratory to determine the physico-chemical parameters.

At the second stage, the cake obtained at the first stage of the experiments was first crushed to 55-60% of the passage through a 2 mm sieve, moistened to 12% with steam at a temperature of 120C and a pressure of 0.5 MPa. Then, the resulting material was thermally treated at a temperature of 120C for 30 minutes with a decrease in the moisture content of the pulp to $7 \pm 0.5\%$ and subjected to final oil extraction in the expelling mode. The results of the experiments are shown in Table 6.

Table 6. The results of obtaining unconventional oils according to the existing technology and using the developed modes of double pressing

Indicators	Type of oilseed raw materials:

	melon	watermelon
The main indicators of seeds		
Oil content of seeds, %	35,3	23,9
Moisture, %	7,2	6,8
Control. Indicators of double pressing of mint seeds without hydrothermal treatment in the "Forpress-expeller" mode		
First-pressed oil output, % (% of total content in raw materials)	20,10 (56,94)	8,23 (34,43)
Final pressing oil output, % (% of total content in raw materials)	2,13 (6,03)	0,38 (1,59)
The total volume of the oil obtained during double pressing, % (% of the total sod.)	22,23 (62,97)	8,61 (36,02)
Acid number of oil, mg KOH/g	0,21	1,74
Chromaticity on the iodine scale, mg/iodine	12	28
Oil humidity, %	0,17	0,11
Sludge content, %	1,22	0,54
Crude protein content, in terms of absolutely dry substances, %	20,27	18,91
Experience. Primary pressing in the "Forpress" mode: Mint humidity-11%, processing temperature-80C, duration-50 min., pulp humidity-7 ± 0.5%		
Yield of prepress oil, % by weight of mint (% of total content in raw materials)	26,22 (74,28)	17,61 (73,68)
Acid number of oil, mg KOH/g	0,19	1,68
Chromaticity on the iodine scale, mg/iodine	8	32
Oil humidity, %	0,18	0,10
Sludge content, %	0,94	0,42
Oil content of prepress pomace, %	10,9	7,5
Humidity of the prepress pomace, %	9,1	8,7
Crude protein content, in terms of absolutely dry substances, %	25,4	24,3
Experience. Final pressing in the "Expeller" mode: Humidity -12%, processing temperature-120 °C, processing duration-30 min., mezg humidity-7 ± 0.5%		
Expeller oil output, % (% of total content in raw materials)	2,9 (8,22)	2,7 (11,3)
Acid number of oil, mg KOH/g	1,25	2,74
Chromaticity on the iodine scale, mg/iodine	17	55
Oil humidity, %	0,12	0,10
Sludge content, %	0,76	0,8

Oil content of expeller pomace, % (% of total content in raw materials)	8,69 (17,51)	3,59 (15,02)
Humidity of expeller pomace, %	10,0	9,1
Crude protein content, in terms of absolutely dry substances, %	26,1	24,1
Oil yield in total (forpress+expeller), % (% of total content in raw materials)	29,12 (82,72)	20,31 (84,98)

Discussions

Hydrothermal treatment is necessary to reduce enzyme activity, decrease the viscosity of the oil released under pressure, and increase the drainage properties of the material. On the basis of the results obtained, a new technology for producing press cake prior to the final pressing is suggested. A new feature of this technology is that, in the second stage of processing, the press cake obtained in the first stage is ground to ensure a 55-60% fraction passing through a 2 mm sieve. Then it is moistened to 12% with steam at a temperature of 120°C and a pressure of 0.5 MPa.

Next, the material is treated hydrothermally at a temperature of 120°C for 30 min, with a decrease in the moisture content in the mash to $7 \pm 0.5\%$, and then it is subjected to the final oil extraction in expeller mode.

In the control experiments, the oil yield at the first press was between 34.43% and 56.94%, and the oil yield from the watermelon was as low as 36.22%, while the oil recovery was not more than 62.97%, resulting in high oil residuals in the cake and the protein content reduced to 20.27%.

In the experimental trials, the oil yield from the watermelon at the pre-press stage was increased to 73.68%, which was 39.25% higher compared to the control, and the oil recovery was 20.31% for the watermelon and 29.12% for the melon, although the color and acid values were slightly higher due to the more intensive processing conditions.

Conclusion

On the basis of characteristics and importance of water and aqueous solutions in oil extraction, an advanced double-pressing technology was developed. The technology involves grinding seeds without hull separation to 60% passing a 1 mm sieve, moistening with steam condensate to 11%, and heat treatment at 80°C for 50 minutes before pre-pressing. The pre-pressed cake is then ground to 60% passing, moistened to 12% with steam at 120°C and 0.5 MPa for 15 minutes before expelling. The unique step of the technology is the repeated moistening of the primary pressed and ground material to 12%, heat treatment for 30 minutes with a decrease in moisture to $7 \pm 0.5\%$, ensuring maximum oil extraction.

In comparison with traditional technologies, the proposed technology has a number of advantages. Mild hydrothermal treatment enhances oil output and facilitates starch hydrolysis to dextrans, improves digestibility by 20-25%, and preserves fatty acid

composition and vitamins. Higher moisture content increases cell swelling and oil extraction. During heating, protein denaturation and steam formation create microcapillaries that improve drainage and facilitate additional oil extraction during expelling.

References:

1. Terlova E.A., Kozhevnikov V.Yu. Activation of the extraction process of vegetable oils in a microwave electromagnetic field //Bulletin of the SSTU. -2012. -№ 2 (66). Issue
2. -pp.171-177. 2. O'ZDST 1199:2009. Vegetable oils. The chromaticity detection method. Tashkent. Gosstandart. -2009. - 11 pages.
3. O'zDSt 1203:2009. Vegetable oils. The method of determining the acid number. Tashkent. Gosstandart. -2009. - 10 pages.
4. O'zDSt 1193:2009. Vegetable oils. Methods for the determination of moisture and volatile substances. Tashkent. Gosstandart. -2009. - 11 pages.
5. Laboratory workshop on fat processing technology / N.S. Harutyunyan, E.A. Arisheva, L.I. Yanova, M.A. Kamysan – M.: Light and food industry. -1983 – 152 p .
6. O'zDSt 1200:2009. Vegetable oils. Methods for determining the peroxide value. Tashkent. Gosstandart. -2009. - 9 pages.
7. Guidelines on research methods, technological control and accounting of production in the fat and oil industry. Under total. edited by Prof. Rzhekhina V.P. and others - L.: VNIIZH. -1967. -vol.2 -661 p.
8. O'zDSt 596:1993. Technical cotton seeds. A method for determining moisture and volatile substances. Tashkent. Gosstandart. -1993. - 18 p .
9. Ed. Nechaeva A.I. Food chemistry. Laboratory practice. –S.Pb.: Giord. -2006. -302 p.
10. Kato, H., Kobayashi, Y., Kanai, G., Iijima, W., Takekura, K., Tokashi, T. Study of microwave pretreatment on oil expression facilities: Effect of microwave pretreatment on oil expression and oil storage of rapeseed. Journal of the Society of Agricultural Structures (Japan), 39(3), doi: 10.11449/sasj1971.39.207. (2008). P. 207–214.
11. Linich E.P. Functional nutrition. Textbook. Ed.: Lan. -2017. -p.180. ISBN: 978-5-8114-2553-2.
12. Mizutani, T., Hashimoto, H. Effect of grinding temperature on hydroperoxide and offflavor contents during soymilk manufacturing process. Journal of Food Science, 69(3), doi: 10.1111/j.1365-2621.2004.tb13379.x. (2004). P. 112–116.
13. Tripathi, M. K., Mangaraj, S., Kumar, M., Sinha, L. K., Giri, S. K., Ali, N. Effect of processing condition on the quality and beany flavor of soymilk. Current Science, 109(6), doi: 10.18520/v109/i6/1164-1171. (2015). P. 1164– 1171.