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INFLUENCE OF THE PRESSING TECHNIQUE AND PARAMETERS ON THE YIELD OF OIL FROM MELON SEEDS

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Melon is a seasonal fruit that is very useful for human health. Kazakhstan ranks 4th in the world production of melons; this indicates the volume of production. Melons are exported to the countries of the EEC (European Economic Union); coverage of the domestic market is provided. However, about 40 % of the crop remains in the fields (overripe ones are not transportable). These fruits are ground and seeds are isolated, some go to the next season as sowing, part is fed to livestock. When processing fruits, the seeds and peel go to waste. Melon seeds are rich in protein substances and oil. They also contain galactan, glucose, gummy, resins. Seed protein consists of glutelin and globulin. This study has considered the seeds of 10 varieties of melons growing in Central Asia. During the research, the characteristics of vegetable oil from melon seeds of different varieties were determined. A comparison of squeezed oil with crushed and not crushed seed kernels is given. Vegetable oil obtained by cold pressing has a good shelf life. Oil extraction technology has been developed, including IR treatment, and pressing of unshelled melon seeds. Based on the results of studies of 10 varieties of melon, the optimal mode of IR heat treatment of seeds at the SVS-200 W unit was determined: for 120 seconds at a distance of 90 mm from the seeds at a radiation flux density of 900 W/m^2. As a result of solving the problem involving the vector optimization criterion, optimal intervals of input parameters were established: the initial humidity of the raw material is 9.15…10.27 %, the speed of rotation of the oil press screw is 0.843…0.895 s^{-1}, the clearance for the yield of cake is 0.750…0.800, oil seed meal temperature at pressing is 87…89 °C, the huskness of the starting product is 7.13…7.23 %. The influence of bottling and storage conditions on the duration of preservation of the main quality indicators by non-refined oil was studied

Keywords: cold pressing, oil from melon seeds, oil yield, physicochemical indicators

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1. Introduction

The production of melons is as follows: South Kazakhstan (64 %), Zhambyl (15 %), Kyzylorda (6.4 %), and Almaty (5.4 %) regions. More than 80 % of melons are grown at peasant and farm enterprises.

The composition of melons growing in Central Asia is similar in varietal conditions and has been studied by different scientists [1, 2].

Various food products are obtained from the fruits of melon, including long-term storage (sorbet [3, 4], juices [5–8], compotes, confitures, jams [9–12], etc.); a technology for extracting pectin from melon peels and producing oriental sweets based on melon [13] is proposed.

Industrial processing produces a large number of by-products, such as stems, fibrous material, peel, and seeds. Most of these by-products are discarded, despite the fact that they are a rich source of many nutrients. In addition, seeds and peel contain biologically active compounds such as phytochemicals. Interest in the seeds of various fruits increases due to the nutritional and beneficial properties of their bioactive compounds. In addition, the seeds are rich in oils, which naturally contain valuable biologically active compounds and antioxidants.

Cucumis melo L. is a world-famous fruit with numerous benefits for human health. However, in addition to the pulp, its by-products, such as the peel and seeds, can also be used in the production of extracts and flour. In addition, in the extraction of oils, secondary raw materials have the potential because they contain phytochemicals with high nutritional and functional capacity. This paper emphasizes the importance of using by-products derived from *C. melo L.* since they have an analgesic, anti-inflammatory, antioxidant, anti-cancer, antimicrobial, diuretic, hepatoprotective, and immunomodulatory effect due to the presence of biologically active compounds. In addition, their use can help minimize the impact on the environment [14].

Cucumis melo L. belongs to the *Cucurbitaceae* family and is consumed worldwide. Its seeds, which correspond to about 10 % of the total mass of fruits, are usually discarded as agricultural waste. Melon seed oil has various beneficial properties, such as antibacterial, antioxidant and antihypercholesterolemic activity, fully justified by the presence of these biologically active compounds. Based on this, melon seed oil has great potential as a functional ingredient. Using these oils as a new, promising, and unconventional source of oil can be a good example of increasing the value of fruit by-products. As a result, meeting the principles of the circular economy and sustainable development contributes to an increase in the income of fruit processing enterprises [15]. Thus, the study of the possibilities and techniques of extracting oil from melon seeds is relevant.

2. Literature review and problem statement

Melon seeds have enormous potential to use as a source of bioactive compounds because these seeds are discarded as waste during the processing of melon. Different works study different aspects of the technology for obtaining oil from melon seeds.

Data are known to optimize the technological parameters of drying in the vibrofluidized bed: temperature (40–60 °C), vibration strength (0.55–1.23), and air velocity (7–11 m/s) for bioactive compounds of musk melon seeds. Under selected drying conditions, the authors obtained the maximum retention of the total content of phenols (977.56 mg GAE/100 g), total antioxidant activity (a decrease in DPPH by 47.84 %). Additionally, the oil yield (50.40 %) and the content of linoleic acid (39.54 %) increased at 54.20 °C, the air velocity of 10.98 m/s, and the vibration intensity of 1.23 at a desirability of 0.917. A greater degree of influence on the retention of biologically active compounds is exerted by temperature compared to the speed of air and the force of vibration. The optimization of the process of drying melon seeds in a vibrofluidized bed confirmed that the intervention of vibration in the fluidization process can lead to the production of high-quality dried seeds. A fluidized bed vibratory dryer can be implemented as an alternative drying method to reduce drying time, processing costs, and ensure better product quality [16]. There are still unresolved issues related to the pressing of oil from melon seeds.

As studies have shown, a comparison of different methods of extracting oil from the seeds of the golden melon gave certain positive results. For the complete utilization of raw materials in food production, golden melon seed oil is extracted using aqueous enzymatic extraction, cold pressing, hot pressing, and ultrasound. In addition, the composition of fatty acids and the nutritional value of extracted GS oils (GSOs) are analyzed. Volatile compounds present in GSO were determined using gas chromatography-mass spectrometry. The flavor profiles of the various GSO samples are further distinguished by an electronic nose. A total of 16 fatty acids were identified in the GSO samples with indices of atherogenicity, thrombogenicity, and nutritional value in the range of 0.142–0.151, 0.366–0.403, and 5.019–5.299, respectively. In addition, 43 volatile compounds have been identified, including esters, hydrocarbons, alcohols, ketones, pyrazines, and aldehydes. The cold-pressed GSO has a fresh and fruity flavor while the hot-pressed GSO has roasted, nutty, fatty, and fruity flavors, and the AEE-derived GSO represents fatty and fruity flavors. The content of acids and peroxides in them of the oil sample is 0.69–079 $mg \cdot g^{-1}$ and 5.17–5.79 $mmol \cdot kg^{-1}$, respectively. The results show that the extraction method affects the composition of fatty acids, taste components, and physicochemical properties of GSO [17]. Thus, it proves that the method of cold pressing remains safer and retains all the nutrients and the oil has a fruity smell, characteristic of fruits.

The study compared the physicochemical performance of melon seeds. The moisture content varies from variety to variety to 4.8–6.3 %, the ash range is 2.5–3.5 %, crude protein is 30.4–37.2 %, and raw cellulose is 1.5–2.7 %. The flavonoid content in the seeds was found to be between 134 and 257 mg HE/kg, and the total phenol content was found to be between 615 and 850 mg of OE/kg. The phosphorus content of melon seeds varied from 5912 to 8964 mg/kg [18]. Therefore, studying the seed performance of each variety is very important for the oil quality indicator.

The profile of fatty acids plays an important role in their stability and nutritional value. Melon seed oil is rich in biologically active components. In Africa and the Middle East, melon seed oil has been used for food and medical purposes for many years [19]. There are many studies on the usefulness of melon oil but there is little information about the quality and compliance with regulatory documents regarding its shelf life.

In addition, given the complexity of processing the melon fruit itself, it is necessary to develop appropriate technologies and intelligent mechanization processes. The engineering properties of the melon should be included in the design of machines for their mechanization as this will further increase their efficiency. In addition, for further mechanization of the processing of melon and melon seeds, it is strongly recommended that the design of the machines be computerized taking into consideration the engineering properties of the melon and its seeds [20].

Higher quality oils are obtained on the hydraulic press; however, low yields have reduced industrial interest in this method. Oils obtained from different varieties showed a high variability in the content of linoleic (51–69 %)) and oleic (15–34 %)) acids. As for vitamin E, γ-tocopherol was the main isoform found in melon seed oil (99.81–456.73 mg/kg), followed by α- and δ-tocopherols. Significant concentrations of tocotrienols (α, β, and γ) were also found. Although all varieties showed positive properties, the principal component analysis (PCA) showed that Honey Dew and Blanco de Ribatejo can be considered as a potential source of polyunsaturated oils with a high concentration of vitamin [21].

Studies have also been conducted on by-products in melon processing and compared with melon pulp. Studies have shown that melon peel and seeds have a higher content of biologically active compounds than pulp, including polyphenols, carotenoids, and oils [22].

In Kazakhstan, there is currently no production of melon oil, which is a raw material for the food industry and medicine, which is also used for the production of dietary supplements and cosmetics. To preserve all valuable substances in vegetable oils obtained by cold pressing, it is necessary to choose the proper rational technological modes and parameters for its extraction.

3. The aim and objectives of the study

The purpose of this work is to substantiate the development of a technology for obtaining vegetable oil with preliminary preparation of melon seeds, IR irradiation, squeezing of non-shelled seeds. This will make it possible to preserve the smell, taste, and nutrients of vegetable oil.

To accomplish the aim, the following tasks have been set:

– to investigate the characteristics of seeds of different varieties of melons;

– to determine the parameters of cold pressing to increase the yield of oil from melon seeds;

– to investigate the physicochemical parameters of oil from melon seeds;

– to investigate the effects of bottling and storage conditions on the duration of preservation of oil quality indicators.

4. The study materials and methods

At the first stage, studies were conducted with the most common in the Almaty region melons of the Myrzachul and Kolkhoznitsa varieties.

Melon seeds are yellow or cream in color, elongated-elliptic. The average length is 0.92 (Kolkhoznitsa) and 1.4 (Myrzachulskaya), the width is 0.41 (Kolkhoznitsa) and 0.59 (Myrzachulskaya) cm. The mass of seeds was about 4.0–5.0 % of the mass of raw materials taken for processing.

The commercial fraction of melon seeds with an initial humidity of 6–10 % was calibrated on a sieve with holes with a diameter of 5 mm. Two fractions were obtained – an oversize one in an amount of about 80–85 % and a standard fraction in an amount of about 15–20 %. The oversize fraction was sent for further processing, the standard one was placed in a glass flask for intermediate storage to be processed further as necessary according to the same scheme.

The oversize fraction was subjected to heat treatment with IR irradiation with a surface temperature of 85 °C to 95 °C and a final humidity of 4.0 % to 5.0 %. To achieve these temperature parameters and the specified final humidity of melon seeds, it is advisable to carry out IR irradiation at a temperature of 65 °C to 100 °C for seeds with an initial humidity of 6.3 % to 9.9 %. In this case, the specific heat flux should be maintained equal to 900 W/m^2, and the distance between IR lamps and a layer of one seed should be 90 mm.

Micronized melon seeds were crushed by a single blow in a centrifugal stream at a rotational speed of 1500 rpm and a load on incoming melon seeds from 160 kg per hour to 170 kg per hour. The resulting meal contains from 25.0 % to 27.0 % of the free fruit shell and about 25.0 % of residue with non-destruction.

The meal was separated on a sieve surface with a hole diameter of 2 mm for preliminary removal of oilseed dust. Then the oversize fraction was divided on sieves with a hole diameter of 3-, 4-, and 5-mm. The residues were taken to control.

The kernel fraction with a fruit shell content of 8 % was sent for heat treatment.

The heat treatment of the kernel fraction of melon seeds by IR irradiation was carried out up to a temperature of 70 °C.

Micronized oilseed material was pressed on a DoLong press with an outlet matrix with a diameter of 6 mm at a screw shaft speed of 40 rpm.

At the free fruit shell control area, it was separated on a sieve surface and in a vertical air flow. The isolated particles of the kernel were diverted to the general flow of the kernel fraction before heat treatment, and the free fruit shell was withdrawn from production. It can be used as a biofuel for the boiler room.

We determined the characteristics of seeds and studied the component and fractional composition of melon seeds according to the procedures generally accepted in the fat-and-oil industry.

In the study, standard determining methods were used: the chemical composition of melon seeds, the mass fraction of moisture was determined. Their fatty acid composition was determined by gas-liquid chromatography from methyl esters. Determining the mass fraction of protein in melon seeds was performed according to the Kjeldahl method. The study of the amino acid composition of proteins was carried out by chromatographic method on the automatic analyzer Kapel -103. The content of the fractional composition of proteins was determined by the Ozzy Osborne method. The oil was stored in a transparent and tinted container, at 10–15 °C, in a place protected from light.

5. Results and discussion of investigating the process of pressing and the quality of vegetable oil from melon seeds

5. 1. Studying the characteristics of seeds of different varieties of melons

Table 1 gives the general chemical composition of the kernel and fruit shell of melon seeds of the harvest of 2020, the varieties "Kolkhoznitsa" and "Myrzachulskaya".

Table 1

General chemical composition of the kernel and fruit shell of melon seeds

Name of indicators	Melon seeds of the variety "Kolkhoznitsa"		Melon seeds of the variety "Myrzachulskaya"	
	Seed kernel	Fruit shell	Seed kernel	Fruit shell
Mass fraction, %: moisture and volatile substances	5.21	8.17	4.96	7.88
Total protein content in terms of a.s.v	42.89	5.12	40.67	5.19
Oil content in terms of a.s.v	38.75	0.69	39.31	0.88
Carbohydrates, including: Fiber	6.15	39.16	7.89	41.89
Sucrose	0.67	0.59	0.66	0.52
Ash	4.15	2.42	4.12	2.14
Nitrogen-free extractive substances	–	43.82	–	41.94

Comparative results of oil pressing after IR treatment of the kernel fraction and whole seeds are given in Table 2. The preparation of the kernel fraction was carried out in the manner described above. An SVS-200W unit was used to treat the seeds. Within 120 seconds at a distance from the seeds of 90 mm (the distance is chosen taking into consideration the fact that the design of the installation makes it possible to cover the entire seed area with a given radiation flux density of 900 W/m^2).

For the melon of the "Kolkhoznitsa" variety, the kernel is 69.1 % of the mass of the whole seed, husks – 30.9 %. The melon of the Myrzachulskaya variety has 64.3 % and 35.7 %, respectively. If we recalculate the yield of oil from the kernel fraction to the output from whole seeds, it turns out that it will be lower than when squeezing whole seeds. Thus, for the melon of the "Kolkhoznitsa" variety, 23.5 instead of 26.0, and for the Myrzachulskaya variety – 19.3 and 24.6. Thus, if we take into consideration only the yield of oil, then it is not advisable to carry out expensive operations to separate the kernel, so further studies on the extraction of oil were carried out on whole seeds.

Table 2

Oil extraction indicators

Indicator	Melon seeds of the variety "Kolkhoznitsa"		Melon seeds of the variety "Myrzachulskaya"	
	kernel fraction	whole seeds	kernel fraction	whole seeds
Initial humidity, %	4.5	5.28	4.0	5.19
Mass fraction of moisture and volatile substances in oil, %	1.03 ±0.1	1.02±0.1	1.04±0.1	1.04±0.1
Oil yield from the weight of the batch, %	34.0	26.0	30.0	24.6
Acid number, mg KOH/g	1.03±0.02	1.10±0.02	0.9±0.02	0.9±0.02
Peroxide number, mole active oxygen/kg	2.05±0.04	2.10±0.04	1.90±0.04	1.97±0.04
Content: β-carotene, %	0.34±0.05	0.30±0.05	0.31±0.05	0.27±0.05
Vitamin E, mg/100 g	48.1±0.18	46.9±0.18	48.5±0.18	47.9±0.18

The studies used seeds of varieties bred in Kazakhstan and Central Asia: Taisia, Zhansaya, Ethiopia, Prima, Altynochka, Kolkhoznitsa, Mayskaya, Muza, Ili, Honey. Melon seeds of these varieties (Fig. 1) are different both in color and in size. Geometric characteristics of seeds: elongated-elliptic; length, 8.0 (Prima), 13.8 (Muse); width, 4.2–5.8 mm, they make up 0.6–2.0 % of the mass of the fruit. The mass of a thousand seeds varies from 41.0 (Honey) to 51.0 (Kolkhoznitsa) gr. Physical indicators of seeds are summarized in Table 3.

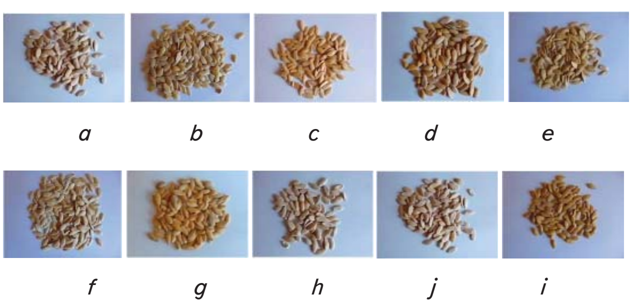

Fig. 1. Melon seeds of the studied varieties: *a* — altynochka; *b* — zhansaya; *c* — Ili; *d* — kolkhoznitsa; *e* — May; *f* — honey; *g* — muza; *h* — prima; *j* — taisiya; *i* — ethiopian

The chemical composition of seeds on average (% in terms of dry matter): water varies depending on the variety on average in the range of 6.0–6.2; lipids are in the range of 25.0–26.5; protein (Nx6,25) – 22.5–25.5; starch and soluble sugars 10.0–11.0; pentosans – up to 8.0; cellulose – 20.0–21.4; ash – 2.5–3.0. The kernel contains up to 50 % oil, and husk – 0.5–0.6 %.

Oil extraction was carried out on an electric screw press DoLong with heating of the screw to 90 °C. The oil yield, calculated as the ratio of the mass of the oil to the mass of the seed attachment, is given in Table 4.

Table 3

Physical parameters of seeds

Variety	Mass of 1000 seeds, g	Mean length, mm	Mean width, mm
Kolkhoznitsa	51.0	11.61	5.20
Muza	50.3	11.55	5.19
Altynochka	48.0	10.67	5.06
Mayskaya	48.0	12.11	5.28
Taisiya	46.0	11.79	5.20
Ethiopian	44.5	11.24	4.92
Ili	44.4	11.29	5.03
Zhansaya	42.0	11.69	5.10
Honey	41.0	11.78	5.18
Prima	32.0	9.66	5.44

Table 4

Oil yield

Variety	Humidity, %	Oil yield, %
Kolkhoznitsa	5.28	26.0
Muza	4.15	22.5
Altynochka	5.19	24.6
Mayskaya	5.10	22.5
Taisiya	5.23	19.0
Ethiopian	6.64	23.5
Ili	5.38	23.5
Zhansaya	5.23	24.6
Honey	5.30	20.0
Prima	5.99	24.0

Based on the results of comparison and analysis of data in Tables 3, 4, it can be concluded that the yield of the oil does not depend on either the size or the mass of a thousand melon seeds.

5. 2. Determining cold pressing parameters to increase oil yield

When planning a study of the effect of husks on the oil yield during cold pressing, whole seeds were chosen as factors x_1 – the type of kernel; whole seeds are taken as 0; 1 – crushed, x_2 – huskness, %; x_3 – seed moisture content, %; y_1 – oil yield, %.

Fig. 2 shows a box plot.

As can be seen from Fig. 2, all factors obey the normal law of distribution, the scope is uniform, the median is strictly in the middle of the box. Therefore, it is possible to apply the Student's criterion and the Fisher criterion to assess the adequacy of our results. Fig. 3 shows a Pareto chart that depicts the most significant factors affecting the resulting factor.

Based on Fig. 3, it can be concluded that the yield of the oil is more influenced by the huskness of the seed fraction, the humidity has a weak effect, and the type of kernels (whole, crushed) does not matter.

The desirability function is shown in Fig. 4.

As can be seen from Fig. 4, the maximum amount of husk at pressing can be 30 %, the minimum – 10 %. It should be noted that the more husks in the fraction for pressing, the worse the quality of the oil; based on this, it was decided to choose 10 % huskness.

The study of desirability profiles can show which levels of predictor variables give the most desired responses of dependent variables (Fig. 5).

Fig. 2. Box plot (“box with whiskers”) of factor values

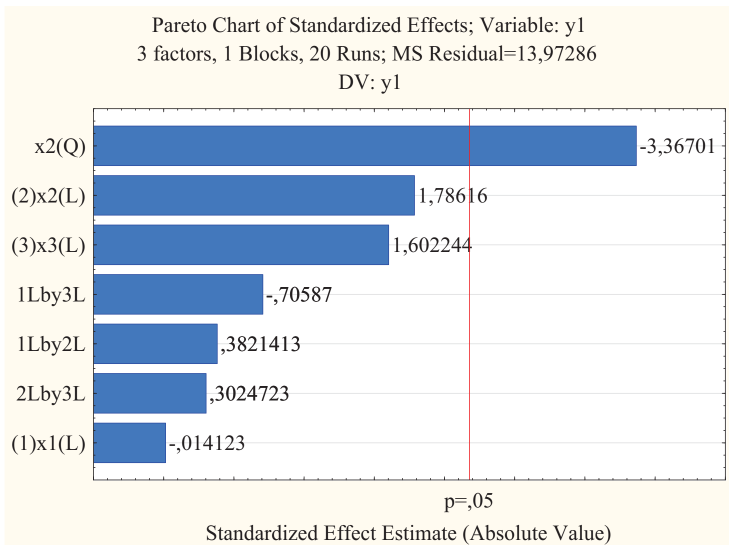

Fig. 3. Pareto chart

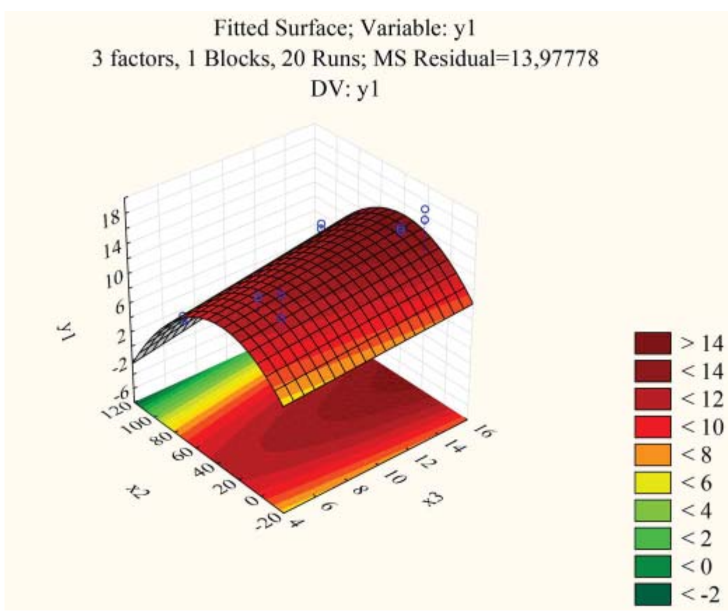

Fig. 4. Oil yield desirability function (3-factor experiment)

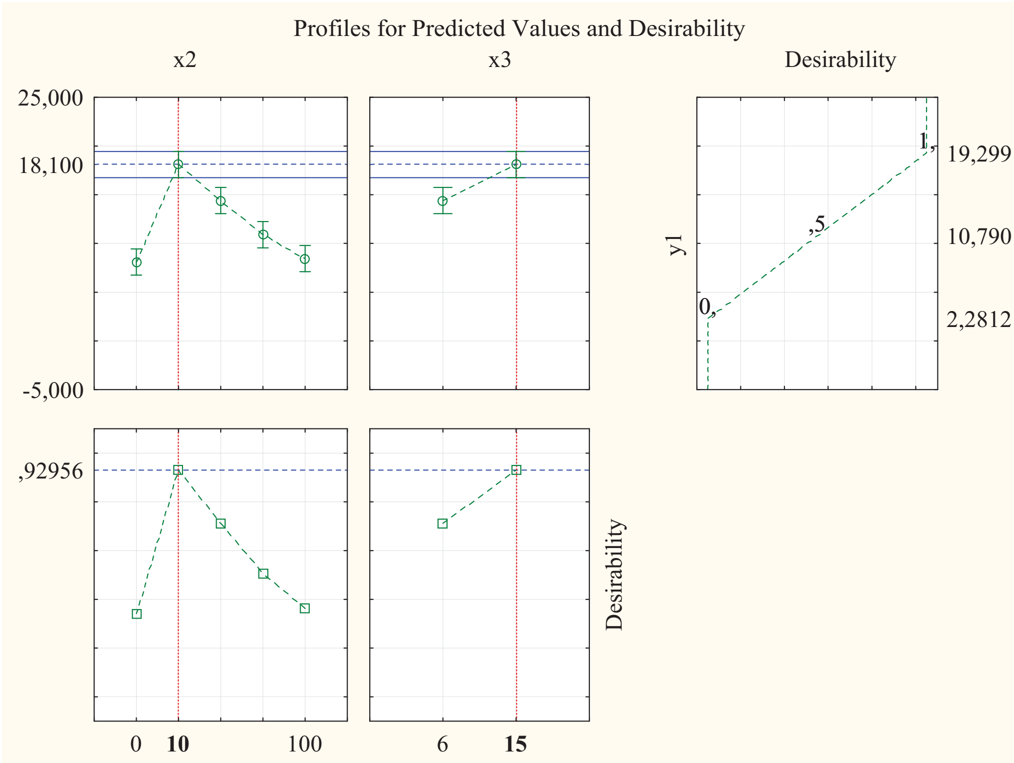

Fig. 5. Desirability profiles

As can be seen from Fig. 5, the desirability function confirms the findings, a huskness of 10 % and a seed moisture content of 15 % give a rational oil yield from melon seeds.

5. 3. Investigating the physicochemical parameters of oil from melon seeds

Oil samples after pressing are shown in Fig. 6.

Melon seed oil is edible, light yellow in color. The fatty acid composition of triacylglycerols of melon oil in comparisonith traditional oils is shown in Table 5.

Fig. 6. Oil from melon seeds of various varieties after pressing

Table 5

Comparison of the fatty acid composition of triacylglycerols

Fatty acid composition	Name of fatty acid	Olive oil	Soybean oil	Sunflower oil	Melon seed oil	Low-erud rapeseed oil (not more than 5 %)	Palm oil
C12:0	lauric	–	–	to 0.1	–	–	0.1–0.4
C14:0	myristic	0.0–0.05	to 0.2	to 0.2	to 2.0	to 0.3	0.5–2.0
C14:1	myristoleic	–	–	–	–	–	–
C16:0	palmitic	7.5–20.0	8.0–13.3	5.0–7.6	10.0-13.1	2.5–6.3	39.0–46.8
C16:1	palmitoleic	0.3–3.5	to 0.2	to 0.3	–	to 0.6	to 0.6
C18:0	stearic	0.5–5.0	2.4–2.5	2.7–6.5	4.8–6.2	0.8–2.5	3.5–6.0
C18:1	oleic	55.0–83.0	17.7–26.1	14.0–39.4	33.0–36.8	50.0–65.0	36.7–43.0
C18:2	linoleic	3.5–21.0	49.8–57.1	48.3–74.0	55.9–57.4	15.0–25.0	6.5–12.0
C18:3	linolenic	–	5.5–9.5	to 0.3	–	7.0–15.0	to 0.5
C20:0	arachidic	0.0–0.6	0.1–0.6	0.1–0.5	–	0.1–2.5	to 1.0
C20:1	gadoleic	0.0–0.4	to 0.3	to 0.3	–	0.1–4.0	–
C20:2	eicosadiene	–	–	–	–	to 1.0	–
C22:0	behenic	0.0–0.2	0.3–0.7	0.3–1.5	0.9–1.2	to 1.0	–

The oil has a pleasant taste, light yellow color, with a fruity aroma. The relative density of oil at 15 °C is 0.918–0.925; refractive index at 20 °C – 1.359-1.479. Iodine number index, 123–183 mg, acid number, 0.90–1.20 mg. Table 6 shows the physicochemical indicators of oils from melon seeds of various varieties. Unsaturated fatty acids 82 %: linolenic acid 1 % (Omega-3), linoleic acid 60 % (Omega-6), oleic acid 21 % (Omega-9). Saturated fatty acids 18 %: palmitic acid 10 %, stearic acid 8 %. Vitamins: A, E, beta-carotene. Minerals: zinc, etc. Caloric content of melon oil is 899 kcal. The influence of the content of the fruit shell in the kernel fraction, as well as the processing of whole grains on the qualitative indicators of melon oil, which determine the degree of its oxidation, the most important indicator of the quality of vegetable oils, has been studied.

Based on the data of Table 6, it can be concluded that the seeds of the variety "Mayskaya" are suitable for long-term storage because they have the lowest acid number, saturated color, and more phosphorus-containing substances.

The characteristics of the quality indicators of melon oil are shown in Table 7.

Analysis of the data given in Table 6 indicates that with an increase in the content of the fruit shell in the samples, there is a slight decrease in the values of all indicators characterizing the quality of melon oil. This leads to the conclusion that the extraction of oil from unspoiled seeds will help to reduce production costs.

Table 6

Physical-chemical parameters of oils from melon seeds of various varieties

Name of indicator, unit of measurement	Taisia	Zhansaya	Ethiopia	Prima	Altynochka	Kolkhoznitsa	Mayskaya	Muza	Ili	Honey
Physicochemical parameters:										
acid number, mg. KOH	1.03±0.11	1.07±0.09	1.02±0.11	1.0±0.13	1.2±0.11	1.1±0.11	0.9±0.11	1.1±0.10	1.3±0.11	1.01±0.09
peroxide number, mmol (1/2O)/kg	2.5±0.27	2.8±0.22	2.3±0.23	2.6±0.27	2.3±0.25	2.1±0.27	1.9±0.22	2.3±0.27	2.7±0.22	2.2±0.27
saponification number, mgKOH/g	204.5±0.95	203.5±0.95	201.3±0.93	204.6±0.95	204.2±0.92	204.1±0.91	204.1±0.95	204.3±0.95	204.2±0.95	203.9±0.95
unsaponifiable substances	0.28±0.035	0.26±0.03	0.28±0.035	0.29±0.033	0.25±0.035	0.21±0.035	0.19±0.035	0.22±0.035	0.20±0.03	0.25±0.035
density	924.0	918.0	924.3	924.1	924.3	924.3	924.5	924.8	924.9	924.1
color number, mg iodine	5±2.034	4±2.034	6±2.034	4±2.034	8±2.034	6±2.034	6±2.034	3±2.034	6±2.034	3±2.034
volatile substances, %	1.03±0.02	1.01±0.02	1.01±0.02	1.05±0.02	1.0±0.024	1.02±0.02	1.05±0.02	1.08±0.02	1.05±0.02	1.04±0.02
mass fraction of phosphorus-containing substances, %	0.10±0.031	0.12±0.031	1.8±0.031	0.12±0.029	0.10±0.030	0.16±0.031	0.15±0.031	0.12±0.031	0.15±0.031	0.7±0.030
β-carotene content, %	0.35±0.02	0.34±0.02	0.33±0.02	0.32±0.02	0.30±0.02	0.30±0.02	0.27±0.02	0.26±0.02	0.27±0.02	0.33±0.02
refractive index at 20 °C	1.475±0.85	1.472±0.83	1.455±0.9	1.478±0.95	1.4±0.03	1.469±0.03	1.469±0.02	1.467±0.93	1.359±0.91	1.475±0.80
Vitamins, E mg/100 g										
tocopherol, % of the total content α	41.9±0.2	41.7±0.2	41.6±0.2	41.3±0.2	41.1±0.2	41.7±0.2	41.5±0.2	39.9±0.2	39.5±0.2	41.7±0.2
tocopherol, % of total γ	58.1±0.09	56.1±0.12	58.2±0.1	57.1±0.12	56.9±0.10	57.3±0.09	57.1±0.09	57.0±0.2	56.9±0.12	58.3±0.11

Note: data are represented as mean and *standard deviation*

Table 7

Characteristics of quality indicators of melon oil depending on the content in the samples of the fruit shell for the variety "Kolkhoznitsa"

Fruit shell content, %	Indicators of melon oil				
	Acid number, mg KOH/g	Peroxide number, mole active oxygen/kg	Phosphorus content, %	Mass fraction of unsaponified substances, %	Color number, mg iodine
8	1.03±0.02	2.05±0.03	0.11±0.005	0.203±0.01	6
15	1.05±0.01	2.07±0.03	0.13±0.002	0.206±0.02	6
24	1.08±0.02	2.08±0.03	0.14±0.002	0.208±0.02	6
Whole seeds	1.10±0.04	2.10±0.03	0.16±0.006	0.210±0.01	6

5. 4. Studying the influence of bottling and storage conditions on the duration of preservation of oil quality indicators

The influence of bottling and storage conditions on the duration of preservation of the main quality indicators of the main quality indicators by unspecified oil was studied. The change in such indicators as acid number, color, sediment, microbiological indicators was studied. After pressing, the oil was placed in a sterilized glass container with a capacity of 25 ml and closed with sterilized lapped stoppers. Batch No.1, bottled in 12 transparent containers, and lot No.2 in 12 dark brown glass containers were stored in diffused lighting.

Within 12 months, with an interval of 3 months, 3 containers of each sample were taken, their study was carried out. The results are given in Table 8.

Experiments have shown that the duration of storage of oil in transparent containers should not exceed 9 months, and in darkened containers – 12 months.

Table 8

Basic indicators of oil from the seeds of melon of the variety "Myrzachulskaya" during packaging and storage

Indicator	Study results			
	before storage	6-month storage	9-month storage	12-month storage
Acid number, mg KOH/g (sample 1/sample 2)	0.90/0.90	1.01/0.90	1.05/0.92	1.12/0.94
Color number, mg iodine (sample 1/sample 2)	6/6	6/6	6/6	8/6
Transparency (sample 1/sample 2)	transparent/transparent	transparent/transparent	transparent/transparent	clouding/transparent
Presence of sediment (sample 1/sample 2)	no/no	no/no	no/no	slight sediment/no
Pathogenic and conditionally pathogenic microflora, including salmonella, in 25 g	not detected	not detected	not detected	not detected
Coliform bacteria, per 0.1 g	not detected	not detected	not detected	not detected
Mold fungi, in 1 g not more than	not detected	not detected	not detected	not detected
Mesophilic aerobic and facultative-anaerobic microorganisms, not more than 1 g (sample 1/sample 2)	1.0×10/1.1 ×10	1.1×10/1.1×10	0.9×10/1.1×10	1.1×10/1.1×10

Table 7 provides information on the change in the characteristics of oil from melon seeds of the "Myrzachulskaya" variety when packed in transparent containers. Changes in the characteristics of the oil during storage in tinted containers were also investigated, the shelf life without loss of quality was 12 months, moreover, the sediment appeared on month 14 of storage.

6. Discussion of results of investigating the process of pressing and the quality of vegetable oil from melon seeds

Analysis of the results in Table 1 shows that the fruit shell contains fiber and nitrogen-free extractive substances, and the content of oilseeds is insignificant, so it was advisable to use the processing method with the separation of the fruit shell.

Our results show that the factors are chosen correctly but the greatest contribution is made by the quadratic values of the amount of husk to the yield of the oil (Fig. 3); the oil yield of melon seeds is not as high as that of oilseeds but the oil from melon seeds has both a nutritional and medicinal orientation. Melon oil has a rejuvenating effect. In addition, the amount of husk has an impact on the quality of the oil. As can be seen from Fig. 5, the desirability function shows that a huskness of 10 % and a seed moisture content of 15 % give a rational yield of oil from melon seeds and do not harm the quality of the oil (Table 7).

In addition, after pressing, secondary raw materials remain in the form of cake (when extracting meal), which can also be used. As the study showed, with cold pressing, the moisture content of the seeds is important, but the husk content also has an impact, both on the yield and on the quality of the oil. This is due to the nature of the oil pressing; with cold pressing, the oil is squeezed with temperature restriction. The temperature inside the chamber is raised by the process, without additional heating. As one knows, the temperature causes rapid oxidation of the oil, thereby increasing the temperature is additionally not desirable for the quality of the oil. Thus, the question arises of preparing seeds for pressing. In the study, we carried out drying with infrared radiation (closest to solar, harmless). The effect of husk content on oil yield is explained by the high content of lignin. When the oil is pressed, lignin plasticizes and clogs a zone before the matrix, the oil press begins to heat up and the oil loses quality. Husk also creates a porous system and facilitates the release of oil.

In comparison with other works and proposed methods, the feature of this study is the study of the influence of oil pressing parameters on its qualitative indicators.

The restrictions are the melon season; the seeds are not stored for a long period (there is a loss of moisture, they are susceptible to infection, etc.)

The disadvantages are the variety of varieties, not all indicators have been studied to the end. The search for a variety of melon seeds with a high oil content continues. The development of this study may involve the selection of a variety of melon with good pulp indicators and with a greater proportion of oil in the seeds.

Of practical importance is to design an oil press for melon seeds and the method for obtaining delicacy oil and high-protein cake.

7. Conclusions

1. In the course of the study, it was determined that fiber and nitrogen-free extractive substances are concentrated in

the fruit shell of melon seeds while the content of oilseeds is insignificant. At the same time, the characteristics of the seeds are studied: the mass of seeds, geometric characteristics, etc. The study showed that neither the size nor the mass of thousands of melon seeds really matters. The yield of oil is determined mainly by the oil content, the content of the husk, the moisture content of the seeds, and the permeability of the shell.

2. As a result of solving the problem with the vector optimization criterion, the optimal intervals of the input parameters of cold pressing were obtained: the initial humidity of the raw materials is 9.15...10.27. The maximum amount of husk at pressing can be 30 %, the minimum – 10 %. It should be noted that the more husks in the fraction for pressing, the worse the quality of the oil; based on this, it was decided to choose 10 % huskness. In addition, the correctness of this decision is confirmed by the desirability function of 0.91, the huskness of 10 %, and the moisture content of the seeds of 15 % give a rational yield of oil from melon seeds.

3. According to the acid number, the greatest indicator is inherent in the Kolkhoznitsa variety, the lowest indicator – in the Prima variety, the rest have the same values on average. According to the peroxide number indicator, the oil of the Zhansaya variety is most susceptible to oxidation, the lowest value is in the Mayskaya variety, and this variety also shows low values for the acid number. According to physicochemical parameters, the Mayskaya variety was selected to obtain oil from melon seeds.

4. It was revealed that the amount of husk at pressing, and the temperature of the chamber and pre-matrix zone affect the quality of vegetable oil, as well as they affect the shelf life. The quality of oil during storage is also significantly affected by the container, with toned containers, the oil does not lose quality for a long time. For the experiment, the Myrzachulskaya variety was chosen because it is widespread, it is a long-stored variety. As can be seen from the results, the indicators of acid numbers are less when the container is tinted, there is also no sediment.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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