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COMPARATIVE STUDY OF FATTY ACID COMPOSITION OF WHITE AND BLACK SESAME OILS AND DEVELOPMENT OF A RELATIVELY EFFICIENT METHOD FOR ISOLATING THE NATURAL ANTIOXIDANT SESAMOL

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The work is devoted to a comparative study of the fatty acid composition of white and black sesame oils, as well as the development of a relatively effective method for isolating the natural antioxidant sesamol.

The purpose of this work was to determine the comparative indicators of the content of fatty and free organic acids in the studied oils by gas and high-performance liquid chromatography, confirm their suitability and further use.

The optimal conditions for obtaining high-quality unrefined oil from sesame seeds for the food and pharmaceutical industries were determined by the method of cold pressing (pressing chamber temperature was 100℃, oil outlet temperature was ≤ 40℃). Under these conditions, the oil yield was 30% and 27%, respectively.

It was shown that finished sesame seed oils contain a highly effective natural antioxidant sesamol (oxyhydroquinone methyl ester) – 0.140 *mg*/*kg*, due to which they can be stored at room conditions for more than 3 years. The extracts of squeezes of sesame oils contain valuable free organic acids: oxalic – 0.017 *mg*/*mL*, malic – 0.02 *mg*/*mL*, fumaric – 0.001 *mg*/*mL*.

Based on the research, the fatty acid composition of oils was determined and a relatively effective method for the complex processing of sesame raw materials was developed to obtain a highly effective natural antioxidant sesamol.

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Introduction. The origins of sesame popularity go back to the distant past. In ancient times in Babylon and some other countries sesame was a symbol of immortality – not in vain it was considered the food of the Gods. Seeds of the sesame plant cultivated since ancient times (more than 7000 years ago) are still used in India,

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Pakistan, Central Asia, China, the Mediterranean countries. Today, sesame is mainly cultivated in Central Asia, India and Transcaucasus, in particular, in the Irind village of the Aragatsotn Province of the Republic of Armenia (RA) [1].

Since ancient times, sesame has been used not only as a culinary seasoning, but also as a raw material for the production of sesame oil, famous for its therapeutic and cosmetic properties [1]. For example, mentions of the healing power of sesame seeds are found in Avicenna's medical treatises. In ancient Egypt sesame oil existed as far back as 1500 BC. It was widely used in folk medicine, when only natural remedies were used as medicines, which makes this product even more deserving of respect. This oil is one of the main means used in Ayurveda (the doctrine of traditional methods of ancient Indian medicine). The Indian science of health Ayurveda prescribes morning rinses with sesame oil, especially for urban residents: removing toxins, strengthening gums and teeth, activating oral receptors, normalizing mucous membrane, strengthening chin muscles – this is far from the full list of the effects from this procedure called "Gandusha". In addition, the Ayurveda system indicates the important prophylactic effect of the product during ear, nose, throat (ENT) infections and it is recommended to lubricate the nasal mucosa before going out [1–3].

Sesame oil is rich in microelements and polysaturated fatty acids (stearic – 4–6%, palmitic – 7–8%, myristic – 0.1%, arachidic – 1%, oleic – 35–48%, linoleic – 37–48%, hexadecenoic – 0.5%). Although sesame seeds contain many useful minerals, such as magnesium, phosphorus and calcium, these minerals do not pass into the oil. Repeated analysis showed that sesame oil, unlike seeds and pastes made of them, did not contain minerals [2, 3].

Despite the high calorie content – 595 *kcal*/100 *g*, sesame oil is also effective for weight loss. Sesamin contributes to slimness, because of its presence the product is called sesame oil. It is sesamin that is the ingredient of many fat-burning complexes. Normalization of lipid metabolism, strengthening of the body and its systems occur with the regular intake of a single table-spoon of the product (90 *kcal*). Squalene, which strengthens immunity, is responsible for regulation of the production of sex hormones and reduction of cholesterol.

Due to the high content of natural antioxidants (in particular sesamol) sesame oil has a high resistance to oxidation and a long shelf life. It is known that sesamol can be isolated from the unsaponifiable part of sesame oil sesamolin by hydrolysis [4]. It is found that sesamol has a noticeable antioxidant effect when the oil is injected into the liver. In terms of effectiveness it does not yield to norhydroguaiaretic acid [4–6]. Sesamol can suppress the DNA damage caused by radiation stress. Ionizing radiation damages cellular DNA, causing chromosomal aberrations and micronuclei in proliferating cells [7].

The enhancement of the activity of important antioxidant enzymes such as catalase, superoxide dismutase and glutathione peroxidase is accompanied by an increase in the level of reduced glutathione. These enzymes play a vital role in preventing cell damage by radicals [7, 8].

Lipid peroxidation is a type of lipid degradation caused by oxidation. This leads to the formation of reactive aldehydes such as malondialdehyde and 4-hydroxynonenal that cause cells damage. Sesamol has been shown to prevent lipid

peroxidation, thereby providing cells protection. Treatment with sesamol reduces plasma cholesterol and triacylglycerol levels in acute and chronic hyperlipidemia mice [9, 10].

Sesamol, the main lignan in sesame seeds *(Sesamum indicum),* has properties that help fight cancer cells, including anti-proliferative activity through various mechanisms such as inhibition of the membrane potential, stopping the growth of cells at different stages, as well as induction of apoptosis [11]. In a study involving the human colon cancer cell line DLD-1, sesamol was used at a dose of 12.5–100 μM. It was found that the transcriptional activity of COX-2 decreased by 50%. It was also found that sesamol used at high doses of 0.5–10 *mM* induced apoptosis in HCT116 all line by increasing intracellular reactive oxygen $\dot{O}_2^-$ in dose dependent manner. This leads to the activation of the c-Jun N-terminal kinases (JNK) signaling pathway, which facilitates mitochondrial damage. This, in turn, leads to the release of cytochrome, which finally activates caspase, causing apoptosis [11]. Considering that the content of biologically active substances (BAS) in medicinal plant material largely depends on the areas of their growth, as well as special significance of the antioxidant sesamol, it is relevant to study the comparative content of BAS in water-alcoholic extracts, fatty-acid composition in unrefined cold-pressed oils and develop a method for isolating sesame from oilseed meal. A particularly unpleasant fact is the smell of rancidity of unsaturated fatty acids under long-term storage conditions, which negatively affects the authenticity of vegetable oils [12].

The purpose of this study was to determine the comparative indicators of the content of fatty and free organic acids in the investigated oils by high-performance liquid chromatography (HPLC) and to develop a relatively effective method for isolating the powerful natural antioxidant *sesamol* from oilseed meal.

Materials and Methods.

Analysis and Characterization of the Feedstock. The objects of the study were the seeds of black and white sesame seeds growing on the territory of the RA, the Irind village, harvest of 2020–2021. Humidity and ash content of seeds were determined according to the methods [1, 3, 6].

Obtaining Oils From Black and White Sesame Seeds. Samples of cold-pressed oils were obtained by pressing white (or black) sesame seeds on an SG 30-1 oil press at a temperature of 100°C in a pressing unit. At the same time, the temperature of the finished oil at the outlet did not exceed 45°C, which meets the requirements for cold-pressed oils. The yield of technical products (white and black sesame oils with a suspension of seed peels) from 1 *kg* of raw material was 290 *mL* and 270 *mL*, respectively.

The obtained technical sesame oils were kept in a special room for a day at a temperature not higher than 14–16°C for settling the oil from the suspension fraction. Then, to obtain finished oils, they were passed through a paper filter after decanting. 270 *mL* and 250 *mL* of transparent sesame oils were obtained with a light yellowish color and a characteristic slightly bitter taste. Finished products were passed for the study of the content of BAS in them (fatty acid composition, iodine number and other indicators) in accordance with the Specifications for them.

Determination of Flavonoids by HPLC. Analysis was performed with a Waters HPLC Alliance 2695 HPLC Separation Module using a Nucleosil C18

column, 4.6×250 (*mm*), particle size 5 *μm*, injection volume 10 *μL* and a flow rate 1.0 *mL*/*min*. A mixture of solvents (methanol : H_2O : acetic acid in a ratio of 50 : 48 : 2) was used as the mobile phase and detection was done at 254 *nm*.

Determination of Organic Acids by HPLC. Quantitative determination of free organic acids was carried out on a Waters Alliance 2695 Separation Module HPLC system. Chromatographic separation was achieved on an Altima C18, 4.6×250 (*mm*) column by isocratic delivery of the mobile phase (water : methanol : acetonitrile : phosphoric acid in a ratio of 100 : 0.5 : 0.5 : 0.1 (%) at a flow rate of 0.7 *mL*/*min*. The presence of three free organic acids (malic, oxalic and fumaric) was determined with a predominant content of oxalic acid – 0.0212 *mg*/*mL*.

Determination of Fatty Acids by Gas Chromatography (GC). In GC experiments, a Thermo Scientific TRACE 1300 gas chromatograph (USA) with a flame ionization detector was used. To separate the components, a Thermo Scientific TR 5MS column with 30 *m*, 0.25 *mm* (internal diameter), 0.25 *m* (film thickness) was used. N_2 was used as carrier gas at a flow rate of 1.2 *mL*/*min* in constant flow mode. A sample volume of 2 *μL* was injected in the "*splitless*" mode. The inlet port was set to 270°C, and the oven temperature was initially set to 40°C for 1 *min*. The oven temperature was increased to 70°C at a rate of 5°C/*min* for 5 *min*, 140°C at 5°C/*min* for 5 *min*, 200°C at 5°C/*min* for 5 *min*, 250°C at 5°C/*min* for 5 *min* and finally up to 270°C at 5°C/*min* for 5 *min*. The maximum oven temperature was set to 270°C.

Preparation of Oil Samples. For sample preparation, 10 *μL* of each oil was dissolved in 1 *mL* methanol/water solution in a ratio of 4:1 (v/v), stored at 4°C and used as needed.

Preparation of Standard Solutions. A standard solution for myristic, palmitic, linoleic, oleic, stearic acids and a mixture of tocopherol was prepared by weighing 10 *μg* of each standard and dissolving them in 50 *mL* of methanol/water in a ratio of 4:1.

Preparation of Methyl Esters of Fatty Acids in Oils. A selected sample of sesame oil weighing 0.1 *g* was placed in a glass test tube and dissolved in 1.9 cm^3 of hexane. Then, 0.1 cm^3 of a solution of sodium methoxide in methanol with a molar concentration of 2 mol/dm^3 was introduced into the hexane solution and after intensive stirring for 2 *min*, the reaction mixture was settled for 5 *min* and filtered through a paper filter. In the presence of fatty acid methyl esters with less than 8 carbon atoms in the chain, filtration was replaced by centrifugation. The obtained solution is ready for use.

Preparation and Purification of Sesamol from Sesame Oil.

Isolation of Sesamolin From Sesame Oil. Canzoneri and Persiabosco, Malagnini and Armanni and Adriani first reported on isolating sesamolin [13–15]. Kaku et al. also obtained sesamolin as a by-product when preparing sesame oil from sesame seeds [16]. The process of using sesame seeds as a starting material, described by Canzoneri and others, as well as experimental processes on isolating sesamolin in the mentioned publications are too long and labor-consuming, and sesamolin together with sesamin and phytosterol is isolated as a by-product.

With this purpose, the oil is dissolved in acetone (1:8) and the mixture is left overnight at –50°C. The liquid fraction, separated from glyceride crystals, is freed

from the solvent, mixed with five parts of isooctane and left to stand in an ice-box at a temperature of about 5°C for three days.

In addition to these disadvantages, the target products also contain accompanying amino acids as undesirable products that make it difficult to purify the final sesamol product. Therefore, a purely biotechnological method for extracting sesamol is not used for industrial production.

Therefore, the improvement of the technological process of the purification method (liberation from concomitant amino acids) is relevant.

Modified Method for Separating Dissolved Triglycerides. To speed up the process of extracting triglycerides, 50 *mL* (45.0 *g*) of sesame oil was poured into a three-tube round-bottom flask equipped with a reflux condenser, a thermometer and a stirrer, 360–400 *mL* of acetone was added and with vigorous stirring the mixture was frozen in a reactor to –70–80°C using dry ice and acetone. Upon reaching the desired temperature, stirring was continued for another 3–4 *h*, after which an abundant layer of white crystals of fatty acid triglycerides was formed on the walls of the flask. The content of the flask was left overnight in the refrigerator with a temperature not higher than +4°C (for quantitative precipitation of triglycerides of fatty acids). The next day, oil samples are completely freed from triglycerides by filtration. The isolated triglycerides can be used to determine the fatty acid composition of the resulting oils.

Distillation of Acetone, Dissolution of the Dry Residue in Methylene Chloride, Separation of a Mixture of Water-Soluble Lipids, Sesamolin, Amino Acids Using Liquid Extraction. Acetone was distilled off from the organic layer on a rotary unit in a sparing mode, and a mixture of methylene chloride with water was added to the resulting viscous residue and stirred until complete dissolution. After turning off the stirrer (after 0.5 *h*), the mixture was completely separated. Because of the sufficiently good solubility, almost all amino acids passed into the aqueous part, as well as sesamolin, which dissolves moderately in water. For the complete transition of sesamolin into the organic fraction, water was added twice and the separation of water-soluble substances is repeated with a chemical yield (more than 90%).

Separation of a Mixture of Amino Acids From Sesamolin and Other Water-soluble Compounds. For this purpose, water was distilled off from 50 *mL* of the total aqueous fraction to 1/4 volume of the initial sample (12.5 *mL*) and the solution was acidified to pH 4–5 by adding 5 *mL* of 2 *N* HCl. Then, the resulting mixture was passed through a column with cation exchange resin in the form of $Ku^{2-}\times 8\ H^{+}$. After passing the entire solution (the acidic aqueous solution with sesamolin is collected), the column was washed with water until neutral pH. Then, the amino acids were desorbed from the surface of the cation exchanger using a 7% ammonium solution. After distillation of an alkaline solution rich in amino acids, a mixture of amino acids with (*S*)–absolute configuration can be obtained, which can be used both in biotechnological processes and as starting reagents for various syntheses.

Extraction of Sesamol From a Slightly Acidic (pH>5) Solution. For this purpose, the acidity of the target solution was lowered to pH≤1 using a 10 *N* HCl solution and the mixture was boiled for 10 *h* until the hydrolysis of sesamolin was completed (by the disappearance of a sesamolin spot or by the unchanged sesamol spot on the TLC plate). Further, the acidity of the target solution was increased to

neutral and water is completely distilled off until technical sesamol crystals appeared, and after three-time recrystallization, pure crystals of the powerful natural antioxidant sesamol – (3,4-methylendioxyphenol) were isolated. The yield of sesamol is 30.0% (0.14 *g*, 0.00096 *mol*) (see Fig. 1).

The melting point (m.p. 62–64°C) and ^{1}H NMR spectra confirmed the authenticity of the target product. This was also proven by counter chemical synthesis (see Fig. 2).

Chemical Synthesis of Natural Antioxidant Sesamol. 6.5 *mL* of methylene chloride was poured into a 50 *mL* three-tube flask, equipped with a thermometer, a stirrer and a reflux condenser, and 0.5 *g* (0.00333 *mol*) of piperonal, 0.85 *mL* (0.00837 *mol*) of 31% hydrogen peroxide and 0.06 *g* (0.00054 *mol*) of selenium dioxide (SeO_2) were added in portions while stirring at room temperature (≤ 25°C). Stirring of the reaction mixture was continued for 72 *h*, 10 *mL* of water was added, and after separation of the layers, the organic layer was successively treated with 6 *mL* of 10% solutions of NH_4SO_3 and Na_2CO_3. After removing the solvent, the precipitate was dissolved in 2 *mL* of CH_3OH, and after adding a solution of 0.39 *g* (0.007 *mol*) of KOH in methanol, stirring was continued for another 7 *h*. Further, the methanol was distilled off in a sparing mode on a rotary unit, and 10 *mL* of water was added to the precipitate and extracted with ether. The aqueous part was acidified with a 10% HCl solution, extracted twice with 6 *mL* of $CHCl_3$ and after drying over $MgSO_4$ and distilling off the solvent, the precipitate was recrystallized from a mixture of CH_3Cl/petroleum ether. The yield of sesamol (3,4-methylendioxyphenol) is 45.6% (0.21 *g*, 0.0015 *mol*).

Results and Discussion. Sesame seeds are small (about 3 *mm* long and 2 *mm* wide) drop-shaped with a nutty flavor and a delicate crispy texture. Depending on the species, they are of different colors: white, yellow and red. The results of the analysis of the main physicochemical parameters of the raw materials under study are presented in Tab. 1.

Table 1

Quality indicators of sesame seeds

Name of indicator	Characteristics	
	white sesame	black sesame
Appearance	the surface of the seeds is clean, without traces of mold	the surface of the seeds is clean, without traces of mold
Color	white, typical for the particular sesame variety	black, typical for the particular sesame variety
Smell	peculiar to sesame seeds	peculiar to sesame seeds
Humidity, %	2 ± 0.1	2.1 ± 0.1
Ash total, %	3.0 ± 0.2	3.1 ± 0.2
Ash, insoluble in 10% HCl, %	0.020 ± 0.002	0.022 ± 0.002

From the data presented in Tab. 1, it follows that the studied seeds by their commodity indicators are of high quality and can be used to obtain sesame oil.

The organoleptic and physicochemical parameters of oil samples obtained by cold pressing using the SG30-1 oil press were determined [17–19]. The optimal temperature in the pressing chamber of the oil press is 100°C, at which the

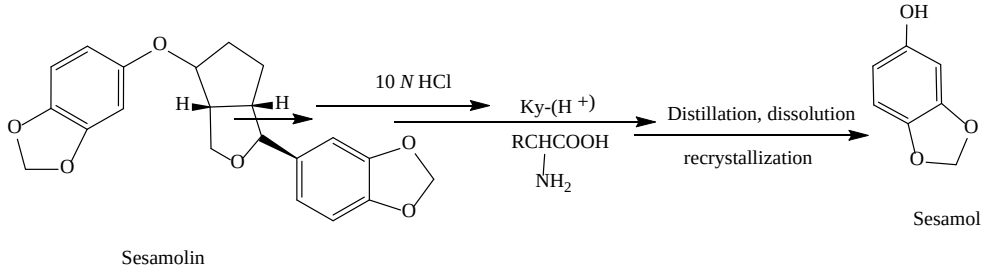
temperature of high-quality unrefined sesame oil used in cooking, pharmaceutical industry and cosmetology does not exceed 40°C at the outlet. Under these optimal conditions, the oil yield from white and black sesame seeds is 30% and 27%, accordingly. Tab. 2 shows the organoleptic and physicochemical parameters of oils.

Table 2

Organoleptic and physicochemical parameters of oil from white and black sesame seeds

Name of indicator	Oil characteristics	
	white sesame	black sesame
Appearance and color	clear oily liquid of light yellow color with a sesame smell	clear oily liquid of yellow color with a black sesame smell
Smell	weak fragrance	weak fragrance
Solubility	completely soluble in chloroform, benzene, acetone, diethyl and petroleum ethers; slightly soluble in 95% alcohol; practically insoluble in water	completely soluble in chloroform, benzene, acetone, diethyl and petroleum ethers; slightly soluble in 95% alcohol; practically insoluble in water
Density at 20°C, g/cm^3	0.916–0.926	0.917–0.928
Refractive index at 20°C	1.465–1.485	1.467–1.490
Acid number, *mg* KOH/*g*, no more	3.0	3.0
Saponification number, *mg* KOH/*g*	192–200	195–200
Iodine number, *mg* I_2/1 g	79–141	80–143
Peroxide number of oil produced in 2020, *mmol* O_2/*kg*	10.0	9.95
Peroxide number of oil after a year storage (2021), *mmol* O_2/*kg*	10.002	9.98
Peroxide number of oil after 2 year storage (2022), *mmol* O_2/*kg*	10.005	10.02
Mass fraction of moisture and volatile substances,%, no more	0.15	0.16
Technological yield, %	30.0	27.0

It follows from Tab. 2, that the peroxide number as the main indicator determining the shelf life of sesame oil has changed slightly over 3 years ($\leq 0.1\%$ in the case of white sesame and 1.3% in the case of black sesame). This is primarily due to the content of powerful natural antioxidants (sesamol, sesamolin and sesamin) in the oils, which prevent the conversion of unsaturated fatty acids into saturated ones, thanks to which the original taste is preserved (the rancidity of the oil is prevented, unlike, for example, linseed almond, peach, etc.).



Scheme. Technological scheme for the isolation of sesamol and protein amino acids.

The modified Scheme for sesamol isolation differs from the existing ones in that it reduces the isolation time from 3 days to one and also allows to isolate valuable protein amino acids of the (*S*)-absolute configuration that can be used both in biotechnological processes and as starting reagents for various syntheses (see Scheme).

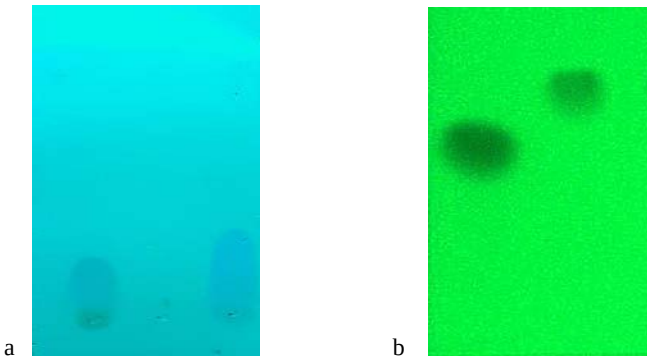


Fig. 1. TLC image of sesamol and sesamin in UV-light at 254 *nm*. Spots 1 and 2 (a) correspond to technical lignans (sesamol and sesamin), and spots 1 and 2 (b) correspond to the same lignans purified after three-time recrystallization from a mixture of solvents chloroform–petroleum ether in a ratio of 1:3 (v/v).

The authenticity of the isolated sesamol was confirmed by ^{1}H NMR (Fig. 2) and determination of melting point (m.p. 62–64°C).

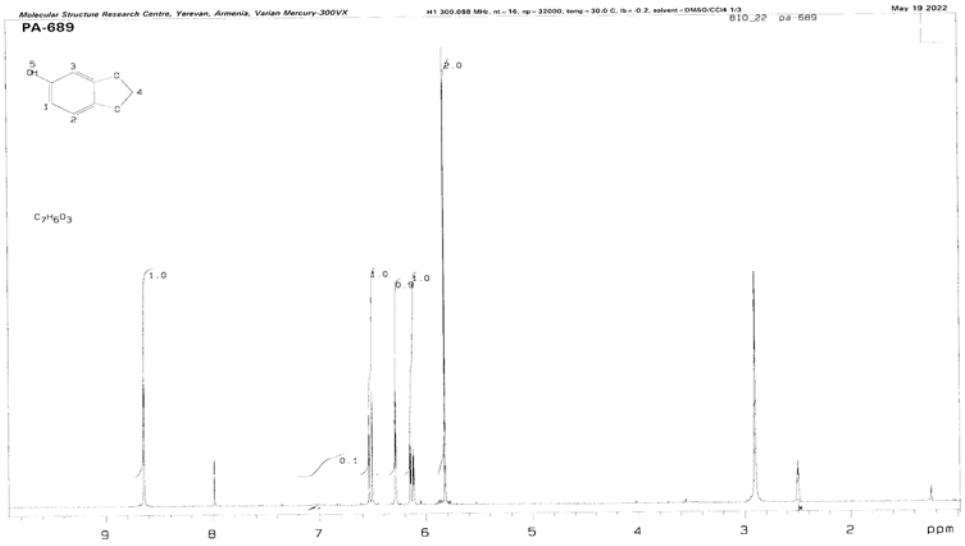


Fig. 2. ^{1}H NMR spectrogram of the isolated natural antioxidant sesamol.

The secondary product of sesame oil production, the natural antioxidant sesamol can be added as a dietary supplement to easily rancid oils to extend shelf life.

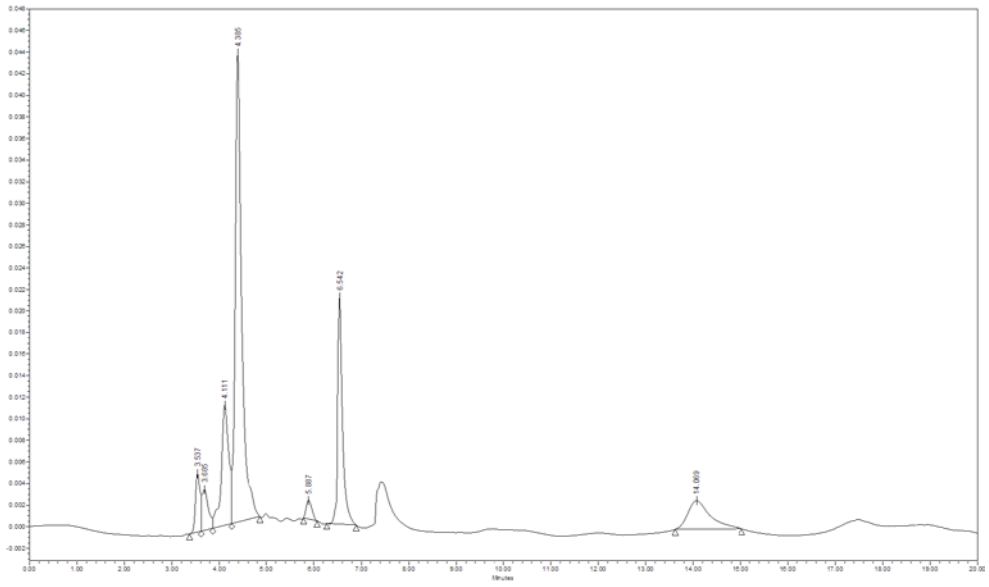
Malic acid is one of the important intermediate products of the metabolic processes of living organisms. Malic acid is involved in metabolism, increases the general tone of the body, helps to lower blood pressure.

Malic acid in the form of E296 is used in the food industry as an acidity regulator and preservative, which prevents reproduction of fungi and bacteria, thereby extending the shelf life of food. Most often E296 is added to bakery products, confectionery, juices and carbonated drinks, wine stuff.

Oxalic acid is widely used in cosmetology as a whitening component for freckles, in medicine and pharmacology. It is the product that is excreted with the urine as calcium salts. In case of violation of mineral metabolism, salts of this acid take part in the formation of stones in the bladder and kidneys.

Fumaric acid esters are used in medicine to treat psoriasis; the sodium salt of fumaric acid is part of the drugs confumin and mafusol.

The content of free organic acids in a 70% alcohol extract of white sesame grapes is presented in Fig. 3.



	Name	Retention time, *min*	Area	% Area	Height	Conc., *mg/mL*
1	*	3.537	36350	4.21	5428	
2	*	3.685	36386	4.21	3795	
3	Oxalic acid	4.111	123577	14.31	11131	0.0165
4	*	4.385	417727	48.37	43471	
5	Malic acid	5.887	14351	1.66	1723	0.0212
6	*	6.542	149124	17.27	21116	
7	Fumaric acid	14.069	86039	9.96	2629	0.001

Fig. 3. The content of free organic acids in a 70% alcohol extract of white sesame (HPLC data).
Note: * are marked those compounds that were not identified as a result of the analysis.

Figs. 4 and 5 reflect the fatty acid composition of white and black sesame oils based on GC analysis of methyl esters of fatty acids obtained according to ГОСТ 51486-99 (points 4.2.1– 4.2.3.3.).

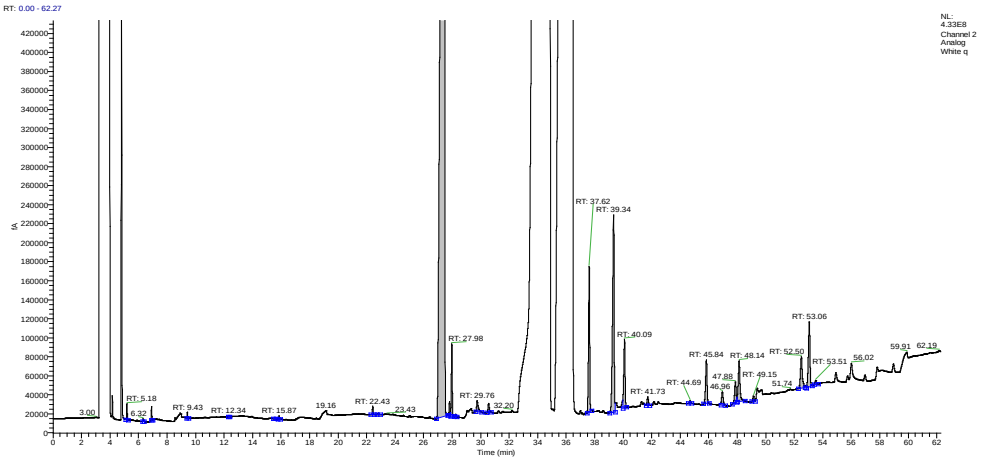


Fig. 4. GC diagram of the fatty acid composition of white sesame oil.

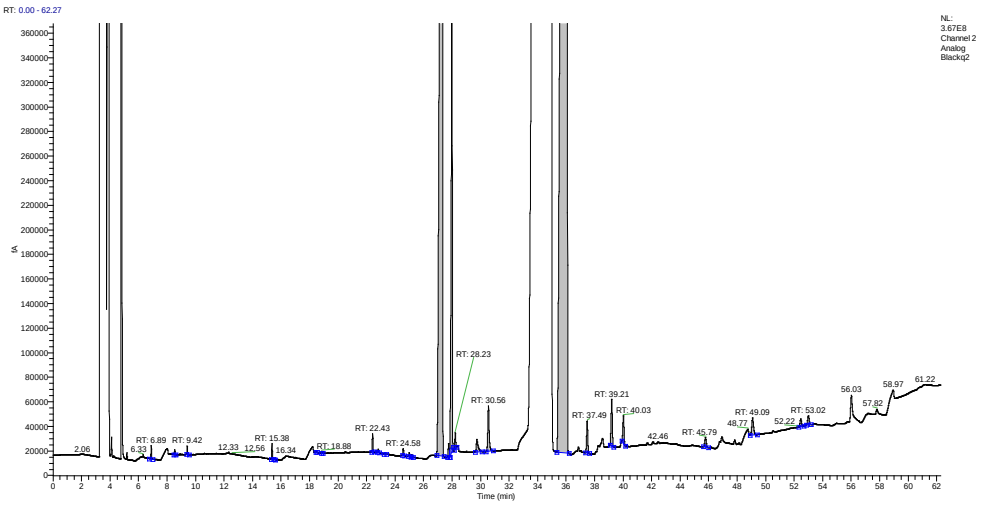


Fig. 5. GC diagram of the fatty acid composition of black sesame oil.

The main components of oil from sesame seeds collected in the Irind village of the RA, harvest 2019–2021 are presented in Tabs. 3 and 4.

Tabs. 3 and 4 show that in white sesame oil only fatty acids of the limiting series were identified: stearic acid (C17 – 1.494 *mg/L*), lignoceric acid (tetracosanoic acid C24 – 0.609 *mg/L*), cys-10 heptadecanoic acid (margaric C17 – 0.546 *mg/mL*), pentadecanoic acid (C15 – 0.043 *mg/L*), lauric acid (C12 – 0.219 *mg/L*).

In black sesame oil, from the limiting series of fatty acids were identified the following ones: stearic acid (C17 – 0.294 *mg/L*), lignoceric acid (tetracosanoic acid C24 – 0.588 *mg/L*), palmitic acid (C16 – 0.257 *mg/L*), cys-10 pentadecanoic acid (C15 – 0.015 *mg/L*), methylpentadecanoic acid (C15 – 0.095 *mg/L*), myristic acid (C14 – 0.014 *mg/L*).

From the above data it can be seen that in terms of the qualitative composition, the studied samples of white and black sesame oils differ only in myristic acid,

and in terms of the quantitative content, white sesame oil with a prevailing content of stearic acid – 1.494 *mg*/*L*, is more preferable.

Table 3

Content of fatty acid composition in white sesame oil (GC data analysis)

Compound	Apex RT, *min*	Start RT, *min*	End RT, *min*	Area	% Area	Height	% Height	Conc., *μg/L*
*	5.18	5.11	5.28	49196.59	0.16	17022.37	0.7	
*	6.32	6.27	6.39	7537.01	0.02	2876.047	0.12	
*	6.92	6.88	6.98	33598.96	0.11	14456.84	0.59	
*	9.43	9.38	9.51	17295.01	0.06	6383.918	0.26	
*	12.34	12.27	12.39	3403.095	0.01	1346.371	0.06	
*	15.55	15.45	15.61	4525.105	0.01	1346.053	0.06	
Methyl laurate (C12:0)	15.87	15.77	15.96	11263.98	0.04	3650.511	0.15	0.219
Methyl pentadecanoate (C15:0)	22.43	22.27	22.55	32903.96	0.11	9011.561	0.37	0.043
*	22.83	22.72	22.95	6493.09	0.02	1623.986	0.07	
*	27.48	26.9	27.68	24353373	80.69	1583721	64.86	
Methyl cis-10 heptadecanoate (C17:1)	27.82	27.7	27.88	66879.12	0.22	14790.47	0.61	0.546
*	27.98	27.89	28.14	340058.3	1.13	76606.79	3.14	
*	28.25	28.18	28.33	12563.39	0.04	2951.193	0.12	
Methyl stearate (C18:0)	29.76	29.65	30.06	97391.07	0.32	11778.13	0.48	1.494
*	30.56	30.41	30.75	63208.71	0.21	9616.024	0.39	
*	37.62	37.45	37.77	902560.9	2.99	153112.1	6.27	
*	39.34	39.05	39.44	1631218	5.4	207802.5	8.51	
*	40.09	39.97	40.22	474400.7	1.57	72000.86	2.95	
*	41.73	41.59	41.86	64539.24	0.21	9206.603	0.38	
*	44.69	44.57	44.79	18478.37	0.06	2867.552	0.12	
*	45.84	45.64	46.03	341593.7	1.13	46085.51	1.89	
*	46.96	46.84	47.17	121585.4	0.4	14593.14	0.6	
*	47.88	47.63	47.98	177018.4	0.59	22549.3	0.92	
*	48.14	47.99	48.53	381650.2	1.26	43185.46	1.77	
Methyl lignocerate (C24:0)	49.15	49.02	49.25	42308.84	0.14	6145.796	0.25	0.609
*	52.5	52.27	52.75	325299.1	1.08	33594.35	1.38	
*	53.06	52.85	53.26	565750.1	1.87	68831.41	2.82	
*	53.51	53.38	53.67	35700.26	0.12	4565.914	0.19	

Note: * are marked those compounds that were not identified as a result of the analysis.

It is interesting to note that mono-, di- or polyunsaturated fatty acids were not identified in the studied samples of sesame oils. This fact excludes the probable consumption of powerful natural antioxidants (sesamol, sesamin ans sesamolin) in complex redox reactions of multiple bonds, due to which sesame oils, unlike all

vegetable oils, retain their original bioavailability and suitability for a long time (more than 3 years).

Table 4

Content of fatty acid composition in black sesame oil (GC data analysis)

Compound	Apex RT, *min*	Start RT, *min*	End RT, *min*	Area	% Area	Height	% Height	Conc., *μg/L*
*	6.89	6.75	7.01	31301.64	0.06	11094.7	0.32	
*	8.54	8.48	8.63	10702.87	0.02	4227.392	0.12	
*	9.42	9.36	9.54	17821	0.03	7065.149	0.21	
*	15.38	15.32	15.47	34773.15	0.07	12933.52	0.38	
*	15.54	15.49	15.6	2239.124	0	905.184	0.03	
*	18.48	18.42	18.53	2327.522	0	820.615	0.02	
Methyl myristate (C14:0)	18.88	18.83	18.93	3839.185	0.01	1451.322	0.04	0.014
Methyl pentadecanoate (C15:0)	22.43	22.35	22.52	53551.11	0.1	14999.3	0.44	0.095
*	22.83	22.76	22.91	9776.725	0.02	2737.893	0.08	
Methyl cis-10 pentadecanoate (C15:1)	23.31	23.23	23.38	5400.516	0.01	1264.161	0.04	0.015
Methyl palmitate (C16:0)	24.58	24.5	24.67	24213.44	0.05	5895.976	0.17	0.257
*	25.01	24.94	25.1	13623.02	0.03	3411.63	0.1	
*	25.19	25.11	25.27	8918.305	0.02	2034.317	0.06	
*	27.33	26.92	27.41	12104673	22.85	1063394	30.86	
*	27.77	27.67	27.83	59457.02	0.11	11372.19	0.33	
*	28	27.84	28.06	2079880	3.93	373393.9	10.84	
*	28.23	28.16	28.32	55502.16	0.1	12791.87	0.37	
Methyl stearate (C18:0)	29.75	29.62	30.1	92841.66	0.18	10126.73	0.29	0.294
*	30.56	30.37	30.86	248251	0.47	36803.41	1.07	
*	36.09	35.35	36.2	37305956	70.42	1746616	50.68	
*	37.49	37.37	37.63	147661.8	0.28	26230.97	0.76	
*	39.21	39.07	39.33	237729.1	0.45	38162.38	1.11	
*	40.03	39.91	40.15	134652.8	0.25	22710.71	0.66	
*	45.79	45.63	45.98	57762.1	0.11	7848.333	0.23	
Methyl lignocerate (C24:0)	49.09	48.9	49.39	127055.6	0.24	14142.75	0.41	0.588
*	52.48	52.33	52.67	47196.87	0.09	6151.397	0.18	
*	53.02	52.85	53.19	57032.28	0.11	7436.654	0.22	

Note: * are marked those compounds that were not identified as a result of the analysis.

Conclusion.

1. The studied samples of sesame raw materials growing in the Irind village, Aragatsotn Province of the RA, are an excellent raw material for the production of high-quality oil, which is in high demand on the world market in the food, cosmetic

and pharmaceutical industries. In particular, the natural antioxidant sesamol, isolated from the primary cold-pressed sesame meal, due to its relatively low cost, can be used as an intermediate starting synthon in the industrial synthesis of the pharmaceutical drug *paroxetine* (Paxil), as well as in Ayurvedic medicine.

2. The optimal conditions (pressing chamber temperature is 100°C, oil outlet temperature is ≤40°C) for obtaining high-quality unrefined oil from sesame seeds for the food and pharmaceutical industries have been determined by the method of cold pressing. Under these conditions, the oil yield was 30% and 27%, respectively.

3. A modified technology for the isolation of natural antioxidants sesamol and sesamin has been developed. It has been shown that sesame seed oils and primary production meal contain a highly effective natural antioxidant sesamol (oxyhydroquinone methyl ester) – 0.140 *mg*/*kg*, due to which the oils can be stored at room conditions for more than 3 years.

4. Primary meal extracts contain valuable free organic acids: oxalic – 0.017 *mg*/*mL*, malic – 0.02 *mg*/*mL*, fumaric – 0.001 *mg*/*mL*.

5. Black and white sesame oils differ only in myristic acid, and in terms of quantitative content, white sesame oil is more preferable, with a transient content of stearic acid – 1.494 *μg*/*L*.

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ՍԵՎ ԵՎ ՍՊԻՏԱԿ ՔՈՒՆՋՈՒԹԻ ՅՈՒՂԵՐԻ ՃԱՐՊԱԹԹՎԱՅԻՆ ԿԱԶՄԻ ՀԱՄԵՄԱՏԱԿԱՆ ՈՒՍՈՒՄՆԱՍԻՐՈՒԹՅՈՒՆ ԵՎ ԲՆԱԿԱՆ ՀԱԿԱՕՔՍԻԴԱՆՏ ՍԵԶԱՄՈԼԻ ԱՆՋԱՏՄԱՆ ՀԱՄԵՄԱՏԱԲԱՐ ԱՐԴՅՈՒՆԱՎԵՏ ՄԵԹՈԴԻ ՄՇԱԿՈՒՄ

Աշխատանքը նվիրված է սպիտակ և սև քունջութի յուղերի ճարպաթթուների բաղադրության համեմատական ուսումնասիրությանը, ինչպես նաև բնական հակաօքսիդանտ սեզամոլի անջատման համեմատաբար արդյունավետ մեթոդի մշակմանը:

Աշխատանքի նպատակն էր իրականացնել գազային և բարձր արդյունավետության հեղուկ քրոմատոգրաֆիայի եղանակներով որոշել հետազոտված յուղերում ճարպային և ազատ օրգանական թթուների պարունակության համեմատական ցուցանիշները, հաստատել դրանց պիտանելիությունը և հետագա կիրառումը:

Սննդի և դեղագործական արդյունաբերության համար քնջութի սերմերից բարձրորակ չզտված յուղ ստանալու օպտիմալ պայմանները որոշվել են սառը մամլման մեթոդով (մամլման խցիկի ջերմաստիճանը 100°C, յուղի ելքի ջերմաստիճանը ≤40°C): Այս պայմաններում յուղի ելքը կազմել է համապատասխանաբար 30% և 27%:

Ցույց է տրվել, քունջութի պատրաստի յուղերը պարունակում են արդյունավետ բնական հակաօքսիդանտ սեզամոլ (օքսիհիդրոքինոնի մեթիլ էսթեր)՝ 0.140 *մգ/կգ*, ինչի շնորհիվ դրանք կարող են պահպանվել սենյակային պայմաններում ավելի քան 3 տարի: Քունջութի յուղերի մզվածքների

էքստրակտները պարունակում են արժեքավոր ազատ օրգանական թթուներ՝ օքսալաթթու՝ 0,017 *մգ/մլ*, խնձորաթթու՝ 0,02 *մգ/մլ*, ֆումարաթթու՝ 0,001 *մգ/մլ*:

Կատարված հետազոտությունների հիման վրա մշակվել է սև և սպիտակ քունջութի սերմերի համալիր մշակման համեմատաբար արդյունավետ տեխնոլոգիա՝ բնական հակաօքսիդանտ սեզամոլի անջատման նպատակով:

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СРАВНИТЕЛЬНОЕ ИССЛЕДОВАНИЕ ЖИРНОКИСЛОТНОГО СОСТАВА МАСЕЛ БЕЛОГО И ЧЕРНОГО КУНЖУТА И РАЗРАБОТКА ОТНОСИТЕЛЬНО ЭФФЕКТИВНОГО МЕТОДА ВЫДЕЛЕНИЯ ПРИРОДНОГО АНТИОКСИДАНТА СЕЗАМОЛА

Работа посвящена сравнительному изучению жирнокислотного состава белого и черного кунжутных масел, а также разработке относительно эффективного метода выделения природного антиоксиданта сезамола.

Целью данной работы было определение сравнительных показателей содержания жирных и свободных органических кислот в исследуемых маслах методами газовой и высокоэффективной жидкостной хроматографии, подтверждение их пригодности и дальнейшего применения.

Определены оптимальные условия получения высококачественного нерафинированного масла из семян кунжута для пищевой и фармацевтической промышленности методом холодного отжима (температура камеры прессования 100°С, температура масла на выходе ≤40°С). В этих условиях выход масла составил 30 и 27% соответственно.

Показано, что готовые масла семян кунжутов содержат высокоэффективный природный антиоксидант сезамол (метиловый эфир оксигидрохинона) – 0.140 *мг/кг*, благодаря чему они могут храниться в комнатных условиях более 3 лет. Экстракты выжимок кунжутного масла содержат ценные свободные органические кислоты: щавелевую – 0,017 *мг/мл*, яблочную – 0,02 *мг/мл*, фумаровую – 0,001 *мг/мл*.

На основании проведенных исследований разработана сравнительно эффективная методика комплексной переработки кунжутного сырья для получения высокоэффективного натурального антиоксиданта сезамола.