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ORGANIC PRODUCT WITH BALANCED COMPOSITION OF ω-6 and ω-3 FATTY ACIDS

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Annotation

The article presents the results of the development of blended vegetable oil with the optimal ratio of polyunsaturated fatty acids from cold-pressed vegetable oils: sunflower, flaxseed, pumpkin. As a result of the experiments, an oil composition was obtained with a polyunsaturated fatty acid ratio of ω-6 and ω-3 of 5:1, with a percentage of 81% sunflower, 12% linseed and 7% pumpkin oil. The resulting organic product is designed for daily consumption to correct the deficiency of essential fatty acids in the diet. The results of the analysis of the limiting values of the characteristics of hydrolytic and oxidative damage - the acid and peroxide numbers during the storage of finished products for 12 months, it was shown that the excess of these indicators over the norm begins with a period of more than 8 months. So, the recommended shelf life of the blended oil is 6 months, at a temperature of 20-25°C.

***Keywords*:** oilseeds, cold-pressed, vegetable oils, balanced composition, diet, monounsaturated fatty acids, polyunsaturated fatty acids, blending, nutritional value.

Introduction

A modern consumer prefers a healthy and safe diet. Due to widespread lifestyle changes caused by many factors in recent years, the demand for natural products is growing. Vegetable oils, which are obtained from organic resources, attract more attention than ever, due to the numerous health benefits [1, 2].

The uniqueness of vegetable oils is determined by the lack of cholesterol and their nutritional value. Vegetable oils are sources of fat-soluble vitamins, sterols, essential oils and other biologically active components that have a positive effect on human health [3].

The main indicator of the quality of dietary fats is fatty acids. Fatty acids of natural oils and fats significantly differ among themselves along the length of the carbon chain, the number and position of double bonds in it, and spatial configuration. This determines the physical, chemical and biological properties that determine the specific characteristics of triacylglycerols that

participate in metabolic processes in the body and form adipose tissue [4].

The fatty acids included in the lipid composition may be saturated or unsaturated. In saturated acids, bonds between carbon atoms are extremely saturated; unsaturated fatty acids contain one or more unsaturated (double) bonds at which hydrogen can join. Single double fatty acids are called monounsaturated (MUFA). Fatty acids with two, three or more double bonds are called polyunsaturated (PUFA). Two polyunsaturated fatty acids - linoleic (omega-6, ω-6) and alpha-linolenic (omega-3, ω-3) are indispensable (essential) for humans since they are not synthesized in the body and must constantly come from the outside, with food products.

PUFA perform several important physiological functions in the body: they ensure the fluidity of biological membranes, affect their permeability, receptor and intercellular interactions; participate in the exchange of other lipids, some vitamins (thiamine and pyridoxine); modulate the functions of the immune system; Essential PUFAs are necessary for the growth and proper development of the brain, organ of vision, sex glands, kidneys, skin, etc. [5]. The stimulating role of polyunsaturated fatty acids concerning the protective mechanisms of the body has been established [6].

Vegetable oils and other fatty products used for direct consumption in food, as a rule, do not have the optimal fatty acid composition, which according to modern concepts is determined not only by the content of polyunsaturated fatty acids (PUFAs) but also by the ratio of omega-6 and omega-3 acids in it, primarily linoleic and linolenic, which are the functional ingredients of the fat products of the healthy nutrition group [7].

Following the recommendations of the RAMS Nutrition Institute, the optimum ratio of PUFAs ω-6: ω-3 in the diet of a healthy person is (9..10): 1. In cases of lipid metabolism, the recommended ratio of PUFAs ω-6: ω-3 is 5:1 and even 3:1. An analysis of the results of monitoring the actual nutrition of the population indicates that these PUFAs enter the body in a ratio of 10:1 to 30:1. Thus, people are constantly experiencing a deficiency in the PUFA of the ω-3 family [8].

There are several ways to solve this problem: the use of drugs containing PUFA omega-3 family; the creation of genetically modified oil crops with a given composition of PUFAs, etc. Blending vegetable oils is the most effective and economically feasible method for producing fat products with a given ratio of PUFAs that meet the requirements of nutrition science. This technique makes it possible to obtain multicomponent systems from vegetable oils and enrich them with fat-soluble vitamins, phospholipids, etc., use them in food products and obtain new food products based on them [9].

Vegetable oils are traditional foods that do not cause complications and adverse reactions in the body, as well as much cheaper dietary supplements, which is important for low-income groups [1, 9].

For research, oils were obtained by the method of "cold" pressing from seeds of sunflower, flax and pumpkin.

Unrefined vegetable oils that have biological value should be used to obtain functional foods. The place of research was the experimental production workshop for the production of vegetable oils of the department "Technology of food and processing industries" of the university.

The choice of starting vegetable oils for blending is determined by their fatty acid composition, availability of production and cost. We used non-traditional, but well-known pumpkin seed oil to enrich biologically active substances, improve performance and extend shelf life. The biologically active substances contained in each of the oils used have a wide spectrum of action; affect the functions of various organs of the human body, as a result of which a complex effect is achieved.

Sunflower oil consists mainly of glycerides of oleic and linoleic acids; contains phospholipids, sterols. Sunflower oil has a high E-vitamin activity, mainly contains α-tocopherol - up to 60 mg [10]. The choice of sunflower oil in the composition of the composition is since this oil is popular and is produced in Kazakhstan in significant quantities and is the most affordable raw material.

Flaxseed oil is especially rich in polyunsaturated essential fatty acids - linoleic and α-linolenic in the optimal ratio for the human body. By fatty acid composition, linseed oil is one of the most valuable vegetable oils [11].

Pumpkin seed oil is obtained from pumpkin seeds by cold pressing. Chemical composition of the product: triglycerides, essential oils, phospholipids, chlorophyll, pectins, sterols, vitamins A, E and F, selenium. Chlorophyll has a tonic effect, enhances the main metabolism, stimulates tissue regeneration, and has bactericidal properties. The rich chemical composition of pumpkin oil allows it to be used as a valuable dietary product that regulates lipid and carbohydrate metabolism, improves the motor function of the gastrointestinal tract and biliary tract, as a source of vitamins and minerals [12].

Materials and research methods

The objects of study are sunflower, flax, pumpkin seeds; sunflower, linseed and pumpkin vegetable oils, blended mixture.

The following research methods were used in the work:

- Determination of the qualitative characteristics of sunflower oil under the requirements of GST 1129-2013 “Sunflower oil. Technical conditions;”
- Determination of the qualitative characteristics of flaxseed oils under the requirements of regulatory documentation ST RK 2645-2015 “Unrefined linseed oil for food;”
- Determination of the qualitative characteristics of pumpkin oil following TR CU 024/2011 Technical Regulation of the Customs Union “Technical Regulation on Oil and Fat Products;”
- Gas chromatographic determination of the fatty acid composition of sunflower, linseed and

pumpkin oil following GST 30623-2018 “Vegetable oils and products with a mixed composition of the fat phase. Method of detecting fraud;”

- Determination of the acid number of sunflower, linseed, pumpkin oil according to GST 5476-80 “Vegetable oils. Methods for determining the acid number;”

- Determination of the peroxide number of vegetable oils according to GST 26593-85 “Vegetable oils. Method for determination of peroxide acid;”

- Determination of the iodine number of oils according to GST 5475-69 “Vegetable oils. Methods for determination of iodine number;”

- Determination of the color number of oils according to GST 5477-2015 “Vegetable oils. Method for determining the color number;”

- Determination of the number of saponification of oils under GST 5478-2014 “Vegetable and natural fatty acids;”

For blending oils, the linear programming method was used. The content and the ratio of linoleic and linolenic acids in the original vegetable oils were taken into account (Fig. 1).

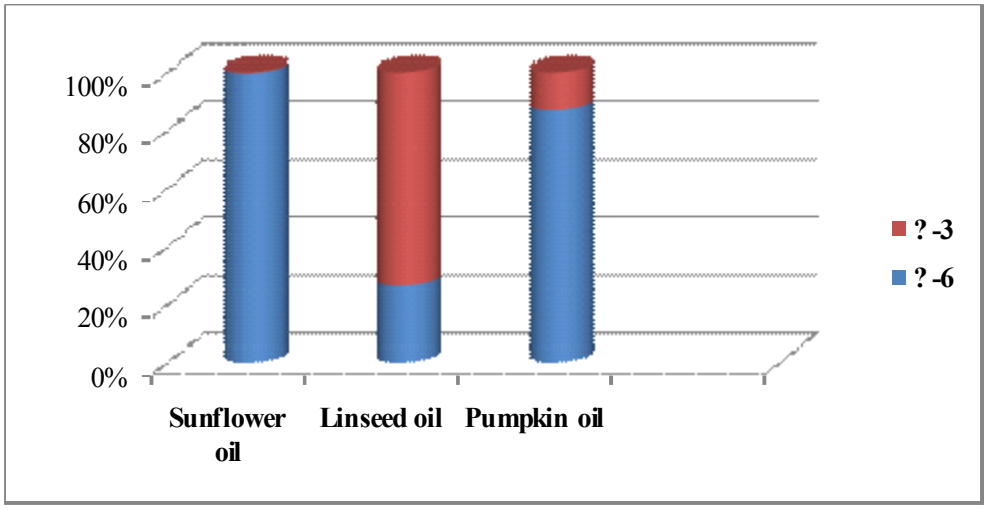

Figure 1 - The content of omega-6 and omega-3 in vegetable oils

Blended oil, consisting of three components, should include: sunflower oil denote by x, linseed oil denote by y and pumpkin oil denote by z. Given that the content of ω-6 fatty acids in sunflower oil is 28.97%, in linseed oil - 17.9%, in pumpkin oil - 45.44, the proportion of these oils in the finished product will have the following form (formula 1):

$$\frac{0{,}2897x + 0.179y + 0.4544z}{x + y + z} \quad (1)$$

The same equation for determining the content of the fraction of ω-3 (formula 2). The content of ω-3 fatty acids in sunflower oil is 0.1%, in linseed oil is 50.1%, in pumpkin seed - 6.83:

$$\frac{0.001x + 0.501y + 0.683z}{x + y + z} \quad (2)$$

With this data, the ratio ω-6:ω-3 will have the form (formula 3):

$$\frac{0.2897x + 0.179y + 0.4544z}{0.001x + 0.501y + 0.683z} \quad (3)$$

For the optimal ratio of fatty acids ω-6:ω-3, we take 5:1 as the upper limit of functional fatty foods for a healthy diet.

The converted equation has the form (formula 4):

$$\frac{0.2897x + 0.179y + 0.4544z}{0.001x + 0.501y + 0.683z} = \frac{5}{1} \quad (4)$$

$$x = 2.5y + 6.38z \quad (5)$$

This equation (5) has an infinite number of solutions. It follows that the desired LC ratio ω-6:ω-3 5:1 is achieved by arbitrary mixing of any two oils and the calculation of the third oil according to equation (5).

It can be seen from the calculations that under this condition, to achieve a ratio of ω-6:ω-3 5:1, the addition of linseed oil should be limited to 10-15%. An increase in the proportion of linseed oil can lead to a shift towards ω-3 acids. The addition of pumpkin oil as a component of blending is fixed at the level of 5-10%, due to the content of carotenoids in it equal to from 380 to 600 mg /100g.

The main results of the research

To obtain vegetable oils used flax seeds, peeled sunflower seeds and pumpkin seeds. To extract the oil, the method of cold pressing on a hydraulic press was used, which allows you to save the native nutrients contained in the seeds.

The table 1 shows the results of analyzes of the physicochemical parameters of unrefined vegetable oils from sunflower, flax and pumpkin seeds.

Table 1 - Qualitative characteristics of unrefined sunflower, linseed and pumpkin oil

Name of indicator	Sunflower oil GST 1129-2013		Linseed oil ST RK 2645-2015		Pumpkin seed oil TR CU 024/2011	
	Norm	Result	Norm	Result	Norm	Result
Transparency, Colour	Transparent golden		Transparent rich golden		There is a slight clouding, dark green	
Smell and taste	Peculiar to sunflower oil, without foreign smell and taste		Peculiar to linseed oil, without foreign smell and taste		Peculiar to pumpkin seed oil, without any foreign smell or taste	
Color number, mg J_2	No more 15	14	No more 40	40	45-39	54
Acid number, mg KOH/g	No more 1.5	1.4	No more 1.5	1.5	No more 4.0	1.2
Mass fraction of	No more	0.18	No more	0.5	0.28-0.34	0.33

phosphorus-containing substances,%	0.20		0.60			
Mass fraction of moisture and volatile substances,%, no more	No more 0.15	0.13	No more 0.2	0.17	0.16-0.21	0.15
Peroxide value, mmol of active oxygen/kg	No more 7.0	6.7	No more 10.0	9	No more 10.0	8.9
Iodine number, g J_2/100	119-145	132	No less 160	176	110-115	110
Saponification number, mg/g	186-194	188	187-196	187	185-205	191

Table 1 shows, all oils according to organoleptic and physicochemical indicators comply with the requirements of regulatory documents. Studies have also established that the cold-pressed method, thanks to the gentle processing regimes of oil-containing raw materials, is effective for producing oils from flax, sunflower and pumpkin seeds, providing the highest quality safe oil with a minimum amount of related substances, including aromatizing ones, which eliminates the need in refining.

To study the stability of oils to oxidation used as raw materials for blending, as well as to calculate the required amount of each of these oils to create a blend, we studied the composition of fatty acids of sunflower, linseed and pumpkin oils. The results of gas chromatographic studies of the fatty acid composition of three types of vegetable oils are presented in the table 2.

Table 2 - Fatty acid composition of vegetable oils

Name of fat acids	Sunflower oil, %		Linseed oil, %		Pumpkin seed oil, %		Regulatory document on the test method
	Norm	Result	Norm	Result	Norm	Result	30623-2018
C 14:0 Myristine	> 0.1	0.05	-	0.06	> 0.1	0.09	30623-2018
C 16:0 Palmitic	4.0-5.5	5.25	3.6-7.2	6.0	10.0-13.0	11.24	30623-2018
C16:1 Palmitoleic	> 0.1	0.03	> 0.2	0.07	> 0.1	0.10	30623-2018
C 17:0 Margarine	> 0.1	0.07	-	-	-	0.10	30623-2018
C 18:0 Stearin	2.1-5.0	4.04	2.5-5.,5	3.63	4.7-6.2	-	30623-2018
C 18:1 Oleic	43.1-71.8	52.21	11.3-24.0	14.13	22.0-39.0	27.05	30623-2018
C 18:2 Linoleic	18.7-45.3	28.97	10.4-18.7	17.9	43.0-59.0	45.44	30623-2018
C 18:3 α-Linolenic	>	0	4	5	-	6	30623

	0.5	.1	8.5-68.5	0.1		.83	3-2018
C 20:0 Arachidic	0.2-0.3	0.09	> 0.3	0.28	> 0.5	0.21	3062 3-2018
C 22:0 Behenic	0.6-1.1	0.1	> 0.2	0.64	> 0.1	0.13	3062 3-2018
C 24:0 Lignoceric	> 0.4	0.08	-	0.18	-	0.06	3062 3-2018

Studies of the fatty acid composition of natural oils confirmed the well-known statement that in nature there is no “ideal” oil with the correct **ratio** of the necessary polyunsaturated fatty acids ω-6 and ω-3.

When planning the creation of formulations of mixtures of oils intended for daily inclusion in the diet, we studied the content of tocopherols and β-carotene in oils. Resistance to oxidative processes also depends on the number and variety of tocopherols [13]. It was found that all the studied oils obtained by cold pressing are characterized by the content of β-carotene and tocopherols in the range: sunflower 0.51-330 mg/kg, flaxseed 0.97-230 and pumpkin 0.84-132 mg/kg respectively.

Thus, by analyzing vegetable oils, studying their organoleptic, physicochemical parameters, fatty acid composition, tocopherol and β-carotene content in oils, we determined one of the most promising formulations based on the fact that organic oil should be available, well stored contain vitamins and biologically active substances.

As a result of our experiments, we obtained a mixture of oil with an omega-6 and omega-3 ratio of 5:1, with a percentage of 81% sunflower oil, 12% flaxseed oil and 7% pumpkin oil. The resulting organic product is intended for daily use by people to correct the deficiency of essential fatty acids in the diet.

Assessing the organoleptic characteristics of the resulting oil blend, it was found that the blended oil has a golden brown color, the taste is pronounced, a pleasant smell (Table 3).

Table 3 - Qualitative characteristics of the organic product

Name of indicator	Characteristic	Technical Regulations of the Customs Union 024/2011 "Technical Regulations for Fat and Oil Products" (as amended on April 23, 2015)
Color	Golden brown	-
Smell and taste	The pleasant smell of unrefined oil is expressed	-
Color number, mg iodine	58	-
Acid number, mg KOH/g	1.25	No more 4.0
Peroxide value, mol of active oxygen/kg	2.54	No more 10.0
Mass fraction, ppm		

β - carotene	0.58	-
tocopherol	304	-

The results of the blending of oils showed that according to organoleptic and physico-chemical parameters, it meets the requirements of TR CU 024/2011 "Technical regulations for oil and fat products."

An analysis of the fatty acids of the test organic product showed that the resulting sample contains linoleic acid 58.75%, linolenic acid 11.69%, MUFA 18.72% and SFA 18.13%.

The mixture of vegetable oil was stored in dark bottles in a dark place, protected from sunlight, at a temperature of 20-25°C for 12 months (Fig. 2). The shelf life of the oil was determined monthly, according to the indicators of the limiting values of the characteristics of hydrolytic and oxidative damage - acid number and peroxide number.

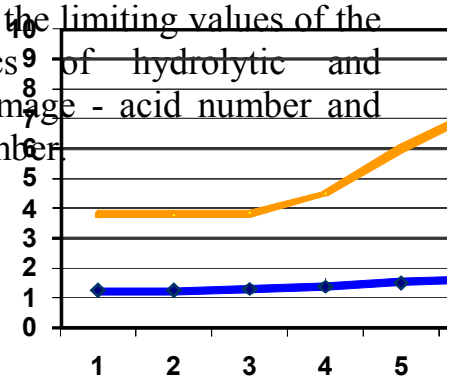

Figure 2 - Dynamics of oxidative processes during storage of a blend of vegetable oils, depending on the storage time

As a result of studies during the storage of finished products, it was shown that the excess of these indicators above the norm begins with a period of more than 8 months.

So, the recommended shelf life of the oil is 6 months, at a temperature of 20-25°C.

Discussion of the obtained data and conclusion

According to the results of studies, we can conclude that the obtained three-component mixture is resistant to oxidation. The ratio of omega-6/omega-3 in the developed mixture is 5:1. It is shown that the created organic product when consumed in the recommended amount, 100% satisfies the body's needs for PUFAs of the ω-6 and ω-3 families at a given ratio. The composition provides high consumer properties of the product - a pleasant taste and aroma, therapeutic effect.

Thus, the blending of vegetable oils is an effective technological solution to achieve a given ratio of unsaturated fatty acids. This direction does not require large financial investments, sophisticated innovative

equipment, time, additional labor. The development of obtaining mixed refined and unrefined oils from local raw materials of organic origin to ensure a balance in the ratio of PUFAs is promising and relevant in Kazakhstan. The production of blended vegetable oils will make it possible to obtain new, competitive types of products that are in demand on the domestic and foreign markets.

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ОРГАНИЧЕСКИЙ ПРОДУКТ СО СБАЛАНСИРОВАННЫМ СОСТАВОМ ω-6 и ω-3 ЖИРНЫХ КИСЛОТ

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Резюме

В статье представлены результаты разработки купажа растительных масел холодного отжима из семян подсолнечника, льна и тыквы с оптимальным соотношением полиненасыщенных жирных кислот. В результате экспериментов была получена масляная композиция с соотношением полиненасыщенных жирных кислот ω-6 и ω-3 5: 1, с процентным содержанием 81% подсолнечного, 12% льняного и 7% тыквенного масла. Полученный органический продукт предназначен для ежедневного употребления для коррекции дефицита незаменимых жирных кислот в рационе. По результатам анализа предельных значений характеристик гидролитического и окислительного повреждения - кислотных и пероксидных чисел при хранении готовой продукции в течение 12 месяцев было показано, что превышение нормы этих показателей начинается в срок более 8 месяцев. Итак, рекомендуемый срок годности смешанного масла составляет 6 месяцев при температуре 20-25°С.

Ключевые слова: семена масличные, холодный отжим, растительные масла, сбалансированный состав, рацион, мононенасыщенные жирные кислоты, полиненасыщенные жирные кислоты, купажирование, пищевая ценность.

ҚҰРАМЫНДА ω-6 және ω-3 ПОЛИҚАНЫҚПАҒАН МАЙ ҚЫШҚЫЛДАРЫ ҮЙЛЕСТІРІЛГЕН ОРГАНИКАЛЫҚ ӨНІМ

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Түйін

Мақалада күнбағыс, зығыр және асқабақ тұқымдарынан полиқанықпаған май қышқылдарының оңтайлы қатынасы бар суық сығылған өсімдік майлар қоспасының алу нәтижелері келтірілген. Зерттеу нәтижесінде полиқанықпаған май қышқылдарының ω-6 және ω-3 қатынасы 5:1 май қоспасы алынды, құрамында 81% күнбағыс, 12% зығыр және 7% асқабақ майы бар. Алынған органикалық өнім диетадағы маңызды май қышқылдарының жетіспеушілігін түзету үшін күнделікті қолдануға арналған. Дайын өнімді 12 ай ішінде сақтау кезінде гидролитикалық және тотықтырғыштық зақымдану - қышқыл мен пероксид санының сипаттамаларының шекті мәндерін талдау нәтижелері бойынша, бұл көрсеткіштердің нормадан асып кетуі 8 айдан асатын кезеңнен басталатыны анықталды. Сонымен, аралас майдың сақтау мерзімі - 20-25°С температурада 6 ай.

Кілттік сөздер: майлы дақылдар, суық сығымдау, өсімдік майлар, үйлестірілген құрам, диета, моноқанықпаған май қышқылдары, полиқанықпаған май қышқылдары, араластыру, тағамдық құндылығы.