УДК 664.34:637.144

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ELABORATION OF VEGETABLE OILS' MIXTURES WITH A BALANCED FATTY ACID COMPOSITION

Optimized mixtures of vegetable oils to ensure a balanced composition of ω-3 and ω-6 acids were developed. The analysis of the raw material base for oil industry of the Republic of Belarus were done. Oils of nine species were chosen for investigation, 5 of which are the traditional raw material for the production of vegetable oils, and 4 are alternative sources, the use of which is possible as enriching components of mixtures of vegetable oils. Imbalance of fatty acid composition of almost all vegetable oils was shown, which proves the need for development of oils mixtures. Different mixtures of vegeta-ble oils that provide the necessary health ratio of polyunsaturated fatty acid were calculated by the method of linear programming formulations. GLC defined co-responsible resulting compositions blends calculated values. It was found that the proposal-conjugated blends No. 1 and No. 2 can be rec-ommended for daily and preventive feeding of population as PUFA ratio is 10 : 1, which fully meets the needs of the human body in the essential fatty acids. Samples No. 3 and No. 4 content the co-ratio of 5 : 1 because flaxseed oil rich in ω-3 fatty acids, which is sufficient for a recommendation of the prod-uct as a therapeutic feeding.

The proposed blends of vegetable oils, are fully compliant with technical regulations on quality and safety of these products. In addition, the proposed mixtures of vegetable oils are undoubtedly due to the economic feasibility of the maximum using of the domestic raw canola, flax and blueberries, which fully corresponds to the direction of import substitution in the Republic of Belarus.

Key words: polyunsaturated fatty acids, blends of vegetable oils, fatty acid composition, gas-liquid chromatography, a method of linear programming, optimized structure.

Introduction. According to the STB 1818-2007 the functional food items are food products intended for systematic use in dietary intake in all age groups of healthy population, reducing the risk of ilnesses related to food, to maintain and improve health due to the presence in its composition physiologically functional food ingredients.

Currently, "healthy" food products are not more than 3% of all known food products. It is predicted that in the next one or two decades, the market potential of these products will exceed 30% of the total food sold. The most dynamically developing product groups in the "healthy" food products sector are dairy, oil and fat produts; thus expanding the range of healthy oil and fat products is very promising [1]. At the same time fat constitutes the second largest part after the carbohydrates in the diet nutrition of the Belarusian population [2].

When developing the functional fatty foods the main technological solutions is to reduce the total calorage, eliminate cholesterol, increase the content of polyunsaturated fatty acids (PUFA), reduce the content of trans-isomers of fatty acid, use the physiologically functional ingredients like vitamins (A, D, B complex, folic acid, tockopherols), minerals (calcium, etc.), fibers, phytosterols and their esters, and other prebiotics [3].

In recent years a lot of new data on the effect of PUFA on the body was received, the cellular and molecular mechanisms of their preventive and therapeutic effects were discovered [4–5]. Polyunsaturated fatty acids manifest a beneficial effect in atherosclerosis, coronary heart disease, hypertension, diabetes mellitus type, obesity, chronic inflammatory diseases, neurodegenerative diseases (e.g. Alzheimer's disease), eye diseases; they reduce the risk of myocardial infarction, cardiovascular stroke, some cancer diseases [6, 7]. The increased consumption of polyunsaturated fatty acids was associated with decreased plasma lipids; the obtained data evidence that most of the effects of lipid-lowering drugs are due to the influence of PUFA [1, 4, 7]. Blood pressure is reduced due to their diuretic action; the effect on rhenium-angiotensin system is like the effect of inhibitors on angiotensin-converting enzyme (ACE); nitric oxide production is enhanced by endothelial cells of blood vessels; the tone of the sympathetic system is relaxed; the tone of parasympathetic nervous system is enhanced [5]. Eicosapentaenoic and docosahexaenoic acids reduce the amount of platelet aggregation, bleeding time increases; therefore they are figuratively referred to as "endogenous aspirin". Several studies have shown that ω-3 fatty acids prevent the development of cardiac arrhythmias [4, 8].

PUFA are ingested with food in different amounts, but their biological action is only realized in a specific ratio of ω-3 and ω-6 fatty acids. In accordance with the recommendations of the Institute of Nutrition the ratio of ω-6 : ω-3 in the diet of healthy people should be 10 : 1, and in the nutritional therapy it ranges from 3 : 1 to 5 : 1. Adequate consumption of ω-3 and ω-6 fatty acids is 11 g per day (including ω-3 – 1 g) [1].

The individual vegetable oils presumably do not provide the ratio of ω-6 and ω-3 fatty acids recommended by the experts. It is known that a prevailing vegetable oil in the dietary regime of citizens in the Republic of Belarus is a sunflower oil, which contains a sufficient amount of ω-6 fatty acid (oleic acid is 19.4 wt % , linoleic acid is 65.9 wt %) and very little amount of ω-3 indispensable acids.

The aim of the research is the development of blends of vegetable oils as functional foods that can satisfy the body's need for PUFA. To achieve this aim it was necessary to accomplish the following tasks:

– to analyze the fatty acid composition of vegetable oils of fat and oil industry of the Republic of Belarus;

– to develop the blends of vegetable oils having a balanced fatty acid composition with ω-3 and ω-6 fatty acids;

– to obtain and examine the physical and chemical quality characteristics of the experimental blends of vegetable oils.

Main part. The objects of the study were selected as the most common in the Republic of Belarus oils, as well as less studied oils that can be used as additives for vegetable oils blends that ensure the necessary balance of PUFA.

At the first stage the fatty acid composition of the investigated oils was studied by gas-liquid chromatography method.

Preparation of fatty acid methyl esters was carried out in accordance with GOST 31665–2012.

The conditions for GLC (gas-liquid chromatography) analysis are the following: the length of silica capillary column is 100 m, its diameter is 0.25 mm, and the applied phase is cyanopropylphenilpolycilacsan. PID detector, carrier gas is nitrogen, injected sample volume is 1 ml. The starting temperature of the thermostat column is 140°C for 4 min, then programmed temperature rise rate of 3°C/min to 180°C; the isothermal mode is for 40 min. Programmed temperature rise rate of 3°C/min to 240°C; the isothermal mode is for 25 min.

The identification of individual components was carried out using reference mixtures of fatty acid methyl esters Restek 35077 and Restek 35079, as well as basing on the known reference retention indices.

The quantitative content of fatty acids (FA) in the samples was determined by using internal normalization Unichrome® package.

As objects of study the following non-conventional oil were chosen:

– oil extracted from the seeds of lingonberry (Vaccinium vitis ideae L.), the Republic of Belarus, Starye Dorogi (sample I);

– oil extracted from the seeds of blueberry (Vaccinium uliqinosum L.), the Republic of Belarus, Starye Dorogi (sample II);

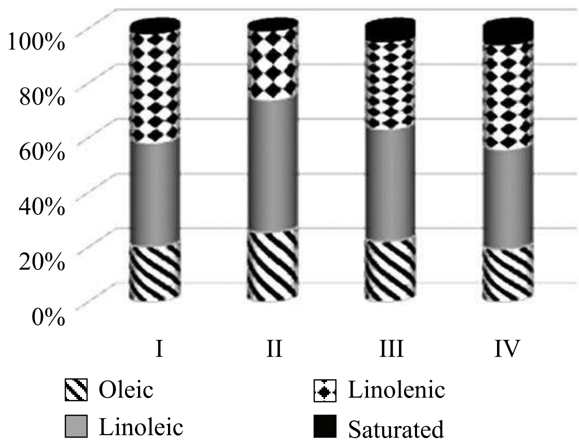
– oil extracted from the seeds of cranberry (Vaccinium Macrocarpon), the Republic of Belarus, Myadel (sample III);

– oil extracted from the seeds of bileberry (Vaccinium corymbosum), the Republic of Belarus, Raubichi (sample IV).

The composition of the test samples is shown in the figure.

As it can be seen, oil fatty acid composition of the berries mainly consists of oleic, linoleic, and linolenic acids. The greatest amount of linoleic (ω-6 acids) is contained in blueberry seed oil ~50 wt %.

While lingonberry, cranberry and bilberry oils are mostly rich in ω-3 linolenic acid (about 40 wt %).



The main content of fatty acids in the berry oils, wt %

Based on the obtained data, cranberry and blueberry oils are of the greatest practical interest as a raw material for optimizing the fatty acid composition of the oil blends, because they have significant amounts of PUFA in their composition. It should also be noted that the possibility of cranberry and blueberry oils extracting in Belarus is due to large-scale berry harvesting industry that is sufficient for commercial processing.

As conventional oils the following samples were studied:

– refined sunflower oil, deodorized, freeze-dried, mark P (sample V);

– unrefined sunflower oil (sample VI);

– refined rapeseed oil, and deodorized (sample VII);

– unrefined soybean oil (sample VIII);

– unrefined food linseed oil (sample IX).

Table 1

Fatty acid composition of oils

Fatty Acid	Fatty acid composition, wt %				
	Sample V	SampleVI	Sample VII	Sample VIII	Sample IX
Myristic	0.08	0.07	0.07	0.07	0.05
Palmitinic	6.62	6.13	5.61	10.04	5.98
Palmitoleic	0.12	0.07	0.19	0.07	0.09
Stearic	3.22	4.38	2.47	5.04	4.88
Oleic	24.78	23.88	41.27	22.33	13.29
Linoleic	62.52	62.74	40.14	52.98	16.12
Linolenic	0.91	0.37	5.13	6.63	54.17

The obtained results concerning the composition of fatty acid triglyceride oils are shown in Table 1. As it can be seen from the results, the composition of acid component remains substantially constant; and the seven major fatty acid components which constitute almost all vegetable oils are shown in the table. However, the quantitative content of individual fatty acids in the triglyceride of the investigated oils greatly differs. The results of GLC analysis show that most of the linoleic acid is in sunflower oil (60 wt %), whereas the content of linolenic acid is low (less than 1 wt %). The data on the composition of oils correlate with the published data [6] and confirm an imbalance of fatty acid composition of the refined and unrefined sunflower oil, one of the most used oils by the population of the Republic of Belarus (95.4 th. t. per year).

Rapeseed and soybean oils have similar fatty acid composition (40–50 wt % of linoleic acid and 5–7 wt % of linolenic acid), which can be used for enrichment of sunflower oil. The highest content of linolenic acid can be noted in linseed oil (up to 54 wt %), which leads to the choice of the oil as a major component in the development of balanced blends products for fatty acid composition.

For the calculation of multicomponent blends of oils the specialists proposed a method that takes into account the required ratio of linoleic and linolenic acids, as well as the original contents of these acids in the oil. The calculation is carried out according to formulas (1) and (2):

$$\frac{m_a \cdot c_a^1 + m_b \cdot c_b^1}{m_a \cdot c_a^2 + m_b \cdot c_b^2} = 10; \quad (1)$$

$$m_a + m_b = 1, \quad (2)$$

where m_a, m_b are masses of vegetable oils, kg; c_a^1, c_b^1 are the concentrations of linoleic acid in a vegetable oil, wt %; c_a^2, c_b^2 are the concentrations of linolenic acid in a vegetable oil, wt %.

The blends of oils were proposed on the basis of the calculations presented in Table 2. When preparing the blends the emphasis was placed onto the functional products and the production costs, as well as the ability to substitute the expensive sunflower and soybean raw oils by domestic rapeseed, linseed and berry oils was taken into account. A rapeseed refined deodorized oil was selected as the base oil in the composition of almost all mixtures.

Blends were prepared in the laboratory by mixing the first two base oils (at 20°C with constant stirring using a magnetic stirrer), followed by minor components of the blends.

The samples of the obtained blends of vegetable oils were subjected to study to determine their organoleptic and physical-chemical parameters (Table 3).

The obtained results for all samples meet the requirements to mixtures of unrefined edible oils by the value of acid and peroxide numbers. However, it should be noted that the samples with the linseed oil have lower acid values and peroxide numbers and that causes some advantage in the production, bottling, and storage of these mixtures. Nevertheless, the results of the research prove the possibility of the production of all the proposed mixtures of vegetable oils, as they are fully correspond to organoleptic and physical-chemical parameters of the requirements TC BY 190239501.136-2006: Vegetable oils – blends.

Table 2

Composition of vegetable oils in the blends

Number of the blend	Sample V	Sample VII	Sample VIII	Sample IX	Sample IV
Blend 1	20%	50%	30%	–	–
Blend 2	20%	45%	30%	–	5%
Blend 3	30%	60%	–	10%	–
Blend 4	10%	80%	–	5%	5%

Table 3

Physical-chemical parameters of the blended oils

Number of the blend	Acid number, mg KOH/g	Peroxide number, ½ O mole/kg	Moisture and volatile substances content, %	The content of linoleic acid, wt %	The content of linolenic acid, wt %	Calculated ratio of ω-3 and ω-6 acids	True ratio of PUFA
Blend 1	0.4	4.4	0.05	44.73	5.83	10 : 1	8.0 : 1
Blend 2	0.5	4.7	0.06	42.68	7.27	5 : 1	5.7 : 1
Blend 3	0.4	3.4	0.06	41.91	7.60	5 : 1	5.5 : 1
Blend 4	0.3	3.2	0.04	28.68	10.84	3 : 1	2.6 : 1
Reference requirements	4.0	10.0	0.2	–	–	–	–

In addition, to assess the correlation of the calculated ratio of PUFA in the composition of the resulting mixtures of vegetable oils, a gas chromatography analysis was conducted. As it can be seen from the data in Table 3, the ratio of linoleic and linolenic acids completely correlated with the expected results. It should be noted that in the case of developing blends with soybean oil, it is appropriate to introduce fruit oils that are rich in linoleic acid, which ensures the required ratio of PUFA.

Conclusion. The composition of plant oils and oils from different types of berries (blueberry, bilberry, cranberry and lingonberry) that grow on the territory of the Republic of Belarus was studied. Analysis of fatty acid composition of triglycerides showed that vegetable oils do not provide the desired ratio of ω-3 and ω-6 acids, which determines the development of blends of vegetable oils.

As a raw material for producing blends, along with the use of traditional oilseeds such as sunflower, soybean, rapeseed and linseed oils, one should pay attention to oil from berries, grown in sufficient quantities in the Republic of Belarus, as an alternative to oilseeds, in order to enrich these oils with optimized blends of vegetable oils. The content of ω-3 fatty acids in oils from blueberries and cranberries is about 40 wt %. The cranberry oil also has a valuable content of linolenic acid (32 wt %).

The proposed four blends compositions which can be used as functional or prophylactic food products are based on the method of linear programming. The compositions of developed blends include sunflower, soybean and flaxseed oils in different proportions, when bilberry oil (5%) is introduced, the blends of the oils fully correlate to organoleptic and physical-chemical parameters of the requirements TC BY 190239501.136-2006: Vegetable oils – blends.

The study of the fatty acid composition of the proposed mixtures of vegetable oils showed that the ratio of ω-3 and ω-6 polyunsaturated fatty acids, necessary for a person to provide a balanced diet was obtained, which allows the data to recommend for daily, prophylactic or therapeutic dietary regime.

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Received 20.02.2015