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Obtaining Vegetable Oils Balanced in the Content of Fatty Acids Based on Rapeseed Oil

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Abstract Study of the technology for obtaining stabilized and enriched in fatty acid composition vegetable oils based on rapeseed oil. The analyses of vegetable oils were carried out according to the methodology described in the "Guidelines for Research Methods, Technochemical Control and Accounting for Production in the Fat and Oil Industry" and SS. To ensure the results' adequacy, parallel experiments were used, sifting out gross errors and checking the homogeneity of the variances and the variance of the experiment's reproducibility. The standard deviation, convergence coefficient, and determinations were evaluated while processing the experimental results. The optimal percentage ratios of cotton: sunflower: rapeseed blended oil in terms of the content of ω-6: ω-3 fatty acids were experimentally investigated, and it was determined that the ratio of 40:20:40, respectively, satisfies the requirements for creating a balanced blend of vegetable oils. By blending the above oils in the developed ratios, stabilization of the oxidative processes of the fatty acid composition is achieved, which leads to a decrease in the appearance of peroxide compounds up to 2.6 times compared with control oils. This article provides information about polyunsaturated fatty acids (ω-3, ω-6, ω-9 in vegetable oils and their role in the human body. In particular, some diseases that occur in the human body, such as cancer, rheumatoid arthritis, asthma, colds, atherosclerosis, thrombosis, and weakness of the immune system, are directly related to the deficiency of this type of fatty acids. Information is provided on the consumption of various types of polyunsaturated vegetable oils and the role of these polyunsaturated fatty acids in the human body. Based on nutritional value and biological efficiency, blended vegetable oils obtained from a mixture of cotton, sunflower, and rasp oils are recommended to be used not only for culinary purposes but also as a fat base in the production of other oils and fat products, such as margarine, spreads, mayonnaises.

Keywords Fatty acids ω-3 and ω-6, Eicosanoids, Trans fatty acids, Eicosapentaenoic acid, Docosahexaenoic acid, Linseed, Rapeseed, Sunflower oils, Blending

1. Introduction

Along with the study of local types of oilseeds grown in the Republic of Uzbekistan, we set ourselves the goal of studying and improving the technology for the production of oils from non-traditional oilseeds by processing them according to the structure of the fatty acid composition, thereby achieving the production of functional types of vegetable oils [1, - S.385-388].

As modern medicine knows, the appearance of up to 70% of diseases in the body is associated with a deficiency of some essential fatty acids. Such diseases can be eliminated by correcting the balance of fatty acids in the body. The need for fats depends on several factors since they are the body's main reserve sources of energy and are part of the membranes of all cells, covering the soft tissues of all organs and protecting them from external influences. The importance of unsaturated fatty acids lies in the fact that they are the building blocks of many eicosanoids produced by the body, which are called prostaglandins and are essential hormonal substances for health [2, -p.201-334; 3, -S. 43-50; 4, -S.184].

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2. Materials and Methods

The studies used vegetable oils, refined sunflower, cottonseed, rapeseed, and linseed oils as objects. The subject of the study is the quality indicators and fatty acid composition of blended oils in different ratios.

Oil analyses were carried out according to the following methods:

- the color of oils on the Lovibond color meter according to USS 1199 [5, -11p.];
- the acid number of oils was determined by USS 1203 and a 1% alcohol solution of phenolphthalein was used as an indicator [6, -10 p.]. The method is based on the titration of an oil sample with an alkali solution in the presence of the phenolphthalein indicator. A

neutralized mixture of alcohol and diethyl ether was used as a solvent for the oil.

3-5 g of oil were weighed into the flask on an analytical balance, 50 ml of a neutralized mixture of diethyl ether and ethyl alcohol and the oil was dissolved. 3-5 drops of a 1% phenolphthalein solution were added here.

The resulting solution was titrated with constant stirring from a burette with a 0.1 N alcoholic solution of caustic alkali until a slightly pink color appeared, which did not disappear within 30 seconds.

A.n. (in mg KOH/g) was calculated by the formula:

$$A.n. = 5.611 \bullet a \bullet k/m$$

where: 5.611 - titer to 0.1 n potassium hydroxide solution, ml; a - the amount of 0.1 n caustic alkali solution used for titration, ml; k - titer correction; m - a mass of analyzed oil, g

- the mass fraction of moisture and volatile substances was determined by USS 1193 [7, 11 p.];

- the degree of oxidation of oils was assessed by peroxide value, determined by the iodometric method according to the standard USS 1200 [8, -9 p.];

- to study the physico-chemical composition of the obtained oils, a Clarus 600 Perkin-Elmer gas chromatograph (USA) was used in the laboratory of applied technologies of the Institute of Bioorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan. Quantitative analysis of fatty acids was carried out under the following conditions: column - Restek, Stabillwax, column length - 60 m, column diameter - 0.32 mm, detector - FID, conveyor gas - nitrogen, thermostat temperature of the temperature gradient - 1-8 min, 80℃; 8-18 min, 130℃; 18-22 min, 180℃; split - 1/10; injection amount - 1 µl. Fatty acids were methylated based on derivatization.

3. Literature Review

According to available data, prostaglandins have a wide range of physiological activity and are active even at concentrations of 10-9 M or less [9, -C.23-78]. They use homeostasis in the body, act on pain receptors, regulate the immune response system and have a bronchodilator effect [10, 654 p.]. In addition, prostaglandins reduce blood pressure by reducing peripheral vascular resistance are involved in the transmission of nerve impulses in the nervous system [11, -p.311-320].

Eicosanoids are so dependent on the composition of fats that the activity of a particular eicosanoid can be controlled by the class of fat from which it is derived. Therefore, it is possible to control and direct human health by controlling the activity of eicosanoids scheduling the body's fat intake. According to their action, three families of fatty acids can be distinguished: ω-3, ω-6 and ω-9. The above two types of fatty acids have the property of forming eicosanoids in large amounts. Fatty acids like ω-9 are important, although not essential. Fatty acids ω-3 and ω-6 types are the primary means of maintaining dietary balance [12, -46 p; 2, - S.211-289; 4, -186 p.].

ω-3 polyunsaturated fatty acids. This type includes three essential fatty acids. These are alpha-linolenic acid, eicosapentaenoic acid and docosahexaenoic acid.

Cancer, rheumatoid arthritis, colds, atherosclerosis, thrombosis, and immune system weakness are directly related to the deficiency of this type of fatty acids. Diseases associated with ω-3 fatty acids constitute the largest group associated with fatty acid deficiency. Fatty acids ω-3 type are the main tool in the formation of the nervous system of the fetus in the womb. The lack of docosahexaenoic acid is observed in diseases of the nervous system.

Unsaturated fatty acids and partially polyunsaturated fatty acids can also be formed in the body as a result of the sequential action of chain extenders (elongas) and desaturation enzymes.

Trans fatty acids have the same energy value as unsaturated fatty acids, but due to their trans isomerism, they are more challenging to use in the body.

The human body's oxidative enzyme system cannot digest trans fatty acids well. The cis configuration is more unstable and prone to catabolism.

According to WHO (World Health Organization) recommendations, trans-fatty acids are classified as nutrients that increase the risk of heart and vascular diseases [13, -C.54-55].

However, sunflower and similar oils are consumed in excess. At the same time, an increase in the concentration in the body of some cold eicosanoids causes vasoconstriction, an increase in blood pressure, and a decrease in bronchial patency. Excessive consumption of these oils leads to a decrease in immune function and exacerbation of diseases such as asthma and arthritis. At the same time, we must not forget about the positive effect of this group of fatty acids on the body. Only ω-6 fatty acids can be converted to the vital essential gamma-linolenic acid. Without it, the body would not be able to produce prostaglandin - an eicosanoid that prevents rapid aging, cancer, arthritis, allergies, asthma and autoimmune diseases [14, -140 s; 15, - S.264-284; 16, -120 s].

As a result of a large number of epidemiological studies, a clear inverse relationship has been established between the consumption of polyunsaturated fatty acids and the amount of cholesterol in the blood and liver and mortality from coronary heart disease [17, -140 s; 18, -p.585-594; 19, -S.37-42].

In patients with atherosclerosis, linoleic acid decreases in the fatty layer of the subcutaneous tissue, and it is assumed that its low dietary intake may be one of the leading causes of the disease [20, -C.30-37; 21, -S.77-80].

Many studies have reported a positive effect of linoleic acid on the serum lipid profile in people with diabetes as the authors found out in the 50s of the last century [22, -p.6-11]. Subsequently, when replacing saturated fats in the diet of patients with polyunsaturated fatty acids of the same high-calorie content, a persistent decrease in lipids and serum cholesterol was observed [23, -C.4-9; 24, -S.58-67]. Consumption of food rich in polyunsaturated fatty acids reduces blood pressure and blood viscosity and improves peripheral circulation [25, -p.620-627]. The lack or absence

of polyunsaturated fatty acids in the human diet inhibits growth, reduces body weight, and damages the central nervous system, liver, kidneys, endocrine glands, and skin [26, -C.56-61].

In [27, -C.56-60] it is stated that the addition of polyunsaturated fatty acids to food has a positive effect on the stability of cell and subcellular membranes on oxidative processes in the Krebs cycle. The help of polyunsaturated fatty acids in oncological diseases has also been determined [28, -C.42-47; 29, -S.288-294].

In recent years, it has been established that consuming a vegetable oil emulsion with a high polyunsaturated fatty acid corrects metabolic disorders of fatty acids in patients [30, -C.132-135].

The active participation of arachidonic acid derivatives in immunological reactions with the help of lipoxygenase and cyclooxygenase has been established. The influence of polyunsaturated fatty acids in the treatment of colds has also been established [14, -140 s; 31, -S.42-47].

Thus, polyunsaturated fatty acids, being direct participants in the food chain, play an essential role in preventing cardiovascular disease, obesity and other chronic diseases.

4. Results

It should be noted that Central Asia's population, including Uzbekistan's population, tends to use the same type of vegetable oils for a long time, which is undesirable. For example, cottonseed and sunflower oils that are not rich in polyunsaturated, especially ω-3 fatty acids, are mainly sold in the food market of Uzbekistan. Due to the deficiency of polyunsaturated fatty acids in the diet, there is a trend towards an increase in overweight among the population and, accordingly, an increase in the number of cardiovascular diseases. Socio-cultural risk factors - consumption of high-calorie foods rich in saturated fats and cholesterol, smoking, a sedentary or inactive lifestyle are the main factors in the growth of chronic diseases [31, -p.73-76]. According to statistics, the annual increase in the number of cardiovascular diseases is 7-8%, even among young people. An aggravating factor is the mentality of cooking and nutrition, which predominantly uses fatty foods with meat and animal fat.

The solution to the above problem is a multi-vector approach. The key ones are the promotion of a healthy lifestyle the development and implementation in industry of technologies that provide healthy nutrition for the population. In this aspect, developing technologies to meet the needs of the population of vegetable oils balanced in fatty acid composition is relevant, since 70% of chronic diseases arise precisely because of the deficiency of certain essential fatty acids.

In studies [32, -p.28-33], a formula of a physiologically complete edible oil for a young and healthy body has been developed. According to him, oils should contain 30% saturated, 50-60% monounsaturated and 10-20% polyunsaturated fatty acids. The amount of linoleic acid for the elderly and people with heart and vascular diseases is on average 40%; the ratio of polyunsaturated and saturated fatty acids is 2:1, the ratio of linoleic and linolenic acids is recommended 10:1.

Nutritionists of the Institute of Nutrition of the Russian Academy of Sciences recommend that the ratio of ω-6 (linoleic, γ-linolenic and arachidonic acids) to ω-3 (α-linolenic, eicosapentaenoic and docosahexaenoic acids) in the diet of a healthy person should be 10:1, and for therapeutic nutrition from 3:1 to 5:1 [33, -S.73-76; 34, –S.45-50].

Linoleic and linolenic acids can be converted into PUFAs with 20 or more carbon atoms and 4-6 double bonds. Such acids provide not only the unique properties of cell membranes, but also are precursors of the biosynthesis of eicosanoids - universal mediators of cell metabolism [35, -C.45-50].

The optimal ratio of fatty acids in vegetable oils, recommended for a healthy diet, is presented in table. 1.

Table 1. The optimal amount of polyunsaturated fatty acids in the diet

PUFA	
ω-6	ω-3
Linol	α-linolene
γ-linolene	Eicosapentaene
Arachidon	Docosahexaene
Recommended amount in the diet	
For a healthy person	
10	1
For therapeutic and prophylactic purposes	
5	1
3	1
Amount of daily consumption, g	
10	1

As can be seen from the data given in the table. 1, the ratio of fatty acids ω-6 to ω-3 for a healthy person should be 10:1, for therapeutic and prophylactic purposes 3-5:1. The daily amount of consumption in the diet of an adult is: 10 g of ω-6 and 1 g of ω-3 fatty acids.

Experts often mention that none of the vegetable oils has an optimal ratio of fatty acids. Table 2 shows the fatty acid composition of vegetable oils available in the Republic of Uzbekistan on an industrial scale.

As shown in table. 2, sunflower oil contains mainly (up to 76%) linoleic acid, but it is not rich in lenolenic acid content and reaches only up to 0.3% of the total fatty acids.

Sunflower high-oleic sunflower varieties contain mainly oleic (up to 92%) acid. As for cottonseed oil consists of the primary 3 fatty acids, i.e. up to 45% linoleic, up to 26.48% palmitic and up to 22% oleic acids. Cottonseed oil does not contain even a small amount of linolenic acid.

Table 2. Fatty acid composition of vegetable oils

Fatty acid	Oil type				
	sunflower	sunflower high oleic	rapeseed	linen	cotton
Myristic	*0,1* - 0,2	-	**0**...1	-	0,1-0,93
Palmitic	5...8	3...5	1...5	4...7	before 26,48
Stearic	1,9...7,0	3...5	0,5...2	2...5	2...5
Arachinoic	0,2...0,5	0...0,3	**0**...1	footprints	before 0,85
Begenovaya	0,4... 0,6	0...1,0	0,5...1,5	-	-
Lignoceric	0...0,4	0...0,4	-	footprints	-
Palmitoleic	0...0,3	0...0,2	footprints	-	before 0,65
Oleic	10...13	70...92	50...65	12...34	18...22
Gadoleic	0...0,5	0...0,2	1...3	-	-
Erucovaya	-	-	0...5	-	-
Linoleic	74...76	2...20	15...30	14...20	До 45
Linolenic	0...0,3	-	8-14	35...65	-

Table 3. The ratio of fatty acids of the studied oils

Oil type	Content of saturated fatty acids, %	Content of unsaturated fatty acids, %	The ratio of unsaturated: saturated fatty acids	ω6:ω3 ratio of fatty acids
cotton	30,0	70,0	2,33:1	250:1
sunflower	11,0	89,0	8,09:1	100:1
rapeseed	10,3	89,7	8,7:1	1,12:1

Linseed oil is drying and unstable due to its high content of tri unsaturated linolenic acid (up to 65%) and unsaturated linoleic acid (up to 20%).

Rapeseed oil contains up to 14% essential linolenic acid and up to 30% linoleic acid, making it more oxidation-resistant than linseed oil. Concerning the total content of unsaturated fatty acids, in rapeseed oil they reach up to 91% due to oleic acid, which reaches up to 65%.

Thus, the study of the composition of commonly used oils showed that 2 out of 5 commonly used oils in the composition contain practically no ω-3 fatty acids.

In order to develop a technology for obtaining vegetable oils with an optimal fatty acid composition, we have carried out experimental studies of blending available oils.

In the experiments, cottonseed and sunflower oils were taken as base oils, which make up a predominant share in the diet of the local population. Rapeseed oil has been used as a source of polyunsaturated ω-3 fatty acids. The ratio of saturated and unsaturated fatty acids of the studied oils is given in table. 3.

Based on the ratio of saturated and unsaturated fatty acids, as well as the ratio ω6:ω3 of fatty acids of the studied oils, the experiments were carried out in 2 directions, i.e. creation of a formulation for the composition of 2- and 3-component blended vegetable oils.

In experiments on creating 2-component blends, combinations of cotton: rapeseed oils were developed in ratios from 20:80 to 80:20, as well as combinations of sunflower: rapeseed oils in appropriate ratios. As the results showed, satisfactory oil ratios were obtained with a ratio of cotton: rapeseed oil in the ratio of 20:80. However, as the analyzes showed, the content of polyunsaturated fatty acids in the mixture was 34.6%, which led to the production of a blend that was not stable to oxidation, because the concentration of saturated fatty acids was found to be lower than necessary.

In the following experiments, we worked on creating a 3-component recipe, i.e. cotton: sunflower: rapeseed oil. Several recipes have been developed based on the desired ratio of polyunsaturated linoleic and linolenic fatty acids. As a result of the research, it was concluded that the ratio of cotton: sunflower: rapeseed oils 40:20:40 satisfies the requirements for creating a balanced blend of vegetable oils. The results are shown in table. 4.

As can be seen from the data given in the table. 4, according to this recipe, linoleic acid content in the blend is 30.3%, which is 4.9 times higher than the content of lenolenic acid, i.e. approaches a ratio of 5:1.

5. Discussions

Our task was to obtain vegetable oil with a given balanced fatty acid composition by blending such oils available for industrial enterprises as cottonseed, sunflower and rapeseed.

As mentioned above, cottonseed and sunflower oils, which are consumed mainly, are far from what is needed for a healthy diet in terms of fatty acid content. Despite the content of a significant amount of polyunsaturated linolenic acid, rapeseed oil does not meet nutritionists' requirements, as it has an unstable composition of fatty acids committed to oxidation.

Table 4

№	Fatty acid (FA)	Quantity FA, %			Content in the blend				everything, in appearance FA %	Balance FA
		cotton.	sunflower.	rapeseed.	cotton.	sunflower.	rapeseed.	total		
saturated FA										
1	Stearic	2,00	4,50	1,60	0,8	0,9	0,6	2,3	18,3	1,8
2	palmitic	25,7	6,20	7,40	10,3	1,2	3,0	14,5		
3	Myristic	1,10	0,00	0,18	0,4	0,0	0,1	0,5		
4	Arachinoic	1,20	0,30	1,10	0,5	0,1	0,4	1,0		
unsaturated FA										
1	Oleic	22,2	51,2	53,1	8,9	10,2	21,2	40,4	41,6	4,2
2	palmitoleic	2,50	0,20	0,60	1,0	0,0	0,2	1,3		
polyunsaturated FA										
1	Linoleic	41,9	33,3	17,3	16,8	6,7	6,9	30,3	36,6	3,7
2	Linolenic	0,14	0,30	15,40	0,1	0,1	6,2	6,3		
	others	3,26	4,00	3,32	1,3	0,8	1,3	3,4	3,5	

Fatty acid composition and balance of fatty acids of the blend of cotton, sunflower, and rapeseed oil in the ratio of 40:20:40

In our opinion, vegetable oils with a balanced composition and ratio of polyunsaturated fatty acids of the ω-6 and ω-3 families can be obtained by blending available vegetable oils: cottonseed, sunflower, rapeseed. The choice of initial vegetable oils for blending is determined by their fatty acid composition, availability and cost.

The blends of cotton, sunflower, and rapeseed oils obtained by us according to a 3-component recipe in the ratio of 40:20:40 meet the requirements for creating a balanced blend of vegetable oils. The experiments' results confirm this to determine the obtained blends' oxidative stability.

To determine the oxidative stability of the obtained blends, we conducted a series of experiments where we studied the oxidative stability of cottonseed, rapeseed and sunflower oils separately and the blend obtained by mixing these oils.

In experiments, 100 g of each type of oil was poured into cylindrical glasses separately and placed on an MM-5 heated mixer, where the oils were subjected to thermal treatment for 180 minutes at 90℃. Then, the change in acid and peroxide numbers was determined.

The results showed that the physicochemical parameters of cottonseed oil subjected to thermal treatment in the above modes did not change significantly. The acid number of sunflower oil increased from 0.31 to 0.41 mg KOH/g and peroxide number from 3.5 to 5.6 ½ O/kg was revealed. As for rapeseed oil, the acid number changed by 0.23 mg KOH/g, i.e. from 0.34 to 0.57 mg KOH/g. The increase in peroxide value is significant and amounted to 2.6 times, i.e. from 2.4 to 6.3 ½ O / kg.

Blended oils subjected to thermal treatment in the above conditions showed higher oxidation stability than the individual oils that make up the blend. The acid number of the blend changed from 0.26 to 0.35 mg KOH/g, i.e. the increase was only 0.07 mg KOH/g. Changes in peroxide value amounted to 0.8 mg KOH/g, i.e., insignificant compared to individual oils.

6. Conclusions

Based on the sources presented in the article, the relevance of creating a technology for producing oils rich in polyunsaturated fatty acids based on cottonseed and sunflower oils is determined. It was revealed that rapeseed oil content can serve as a donor of ω-3 fatty acids.

We experimentally investigated the optimal percentage of cotton: sunflower: rapeseed blended oil in terms of the content of ω-6: ω-3 fatty acids. It was determined that the ratio of cotton: sunflower: rapeseed oils 40:20:40 satisfies the requirements for creating a balanced blend of vegetable oils.

Based on the nutritional value and biological efficiency, blended vegetable oils are recommended for culinary purposes and as a fat base in producing other fat-and-oil products, such as margarines, spreads, and mayonnaises. these products are widely used in the human diet.

The advantages of using blended vegetable oils to provide the human body with PUFAs (linoleic and linolenic) over biologically active additives and drugs containing them are that vegetable oils are relatively inexpensive, traditional food products, do not cause complications and adverse reactions in the body, and also much cheaper than dietary supplements, which is vital for low-income groups.

The introduction of combined vegetable oils into the diet has medical and social significance and creates theoretical and economic prerequisites for producing a wide range of them.

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