ATLANTIS PRESS

Advances in Engineering Research, volume 151

International Conference on Smart Solutions for Agriculture (Agro-SMART 2018)

Study of Physiological Properties of Salad Oils Used in Healthful and Dietary Meals

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***Abstract*— Human life quality and activity are greatly influenced by nutrition since unhealthy diet can entail chronic diseases. Therefore, the authors of the paper make an attempt to dwell on some kinds of food products that are consumed by people on a daily basis, namely oils. The paper deals with the functional food that performs the energy function, as well as improves human being health. The authors of the paper put emphasis on fatty products, particularly vegetable oils that are not paid enough attention in the scientific literature. The polyunsaturated fatty acid content, physical and chemical parameters of vegetable oils available on the Russian market were studied. Two samples of salad oils, their biochemical parameters, composition and fatty acid content were characterised using GOST standards. The experiments were performed using white male rats, which were fed with salad oil. These experiments allowed assessing in the rats' bodies the amount of sulfur, an increase of which can lead to the increase in relative vital mass coefficients (heart, kidneys, liver, spleen) and demonstrate a certain negative impact on the organism of the rats, consuming salad oil containing sulfur.**

***Keywords*— composition, salad oil, vegetable oil, physiological properties**

I. INTRODUCTION

At present, Russia and other world countries pay much attention to healthy lifestyle and healthy nutrition since it is proved that unhealthy diet is one of chronic disease risk factors [6, 9, 10, 24, 28].

Functional food is quite often perceived by consumers as medical and is opposed to traditional food. However, these are food products intended for systematic in dietary intake by all age groups of the healthy population. Functional food is the food that performs not only the energy function supplying us with energy and delivering plastic material for body structure, but it is also the food that improves our health and condition, reduces risk of various diseases. Such food products have a great impact on one or several body functions or its certain organs and systems [11-22, 32].

The simplest and economically viable way of creating fatty products satisfying the above requirements is mixing (blending) of oils having different composition before they are included into the ingredients of any product. Among food items produced by oil and fat industry the emulsion products (spread, margarine, sauce) are the most suitable for transformation. They are supplemented with special ingredients for giving them functional properties, while not enough attention is paid to the value of vegetable oils forming the formula for these products [23, 27, 30].

There are some domestic and foreign studies on this matter. Skoryukin A.N. suggests the technology to receive and apply blended fatty products with optimal polyunsaturated fatty acid content. The polyunsaturated fatty acid content and physical and chemical parameters of vegetable oils available on the Russian market was studied: refined (sunflower, soya, rape, corn, cameline) and unrefined oils (sunflower, flaxseed, cameline and wheat germ oil). The oxidation of blended oils with the use of advanced technique was studied. There is an assumption on the possibility of increasing the efficiency of vitamin E and B-Carotene due to their increased physiological demand. Kopylov M.V. developed a cold pressing technology of vegetable oil-bearing crops with subsequent blending. He justified the change of rheological characteristics of obtained blends of vegetable oils. Shematonov D.V. developed the functional technology of creamy-vegetable spread, proposed the methodology of receiving vegetable oil mixes characterized by balanced fatty acid content. The methodology is based on the principles of balancing the fatty acid content of two- and three-component mixes of vegetable oils satisfying modern physiological requirements. Savelyev I.D. studied the technology of functional creamy-vegetable spread using complex emulsifiers. He managed to develop models describing the dependence of organoleptic and physical-chemical parameters of spread on fat mass fraction of a final product and on the content of emulsifier and liquid vegetable oil. However, these studies do not fully reflect the influence of received products on a human body and do not demonstrate health properties of received blends [24-26, 28, 29, 31-33].

Thus, the creation of balanced recipes of fatty products having increased nutrition value with improved fatty acid content, medical effect and enriched with lipid soluble vitamins may be considered as an important aspect of modern nutrition, which fosters the development of some interrelated branches of oil and fat industry. Modern food production reached a new step of its development when the food program shall satisfy not only the needs of the population for certain food products, but also ensure their basic nutrient balance. One of such products is salad oil [7, 8, 21].

In recent years the scholars may more attention to physiological properties of vegetable oils. The postmortem and toxicological study on laboratory animals receiving highly erucidic oils revealed some myocardial necrotic changes, decreased activity of liver glucose 6-phosphatase and adenyl cyclase during lipid myocardial infiltration, deceleration of adenosine triphosphate synthesis, skeletal muscles obesity, kidneys disorder, liver cirrhosis [2, 5, 27].

It shall be noted that with the introduction of non-erucidic oils to diets of animal the above specified problems still remained, but were less expressed. Hence, not only erucidic acid, but also other oil ingredients, such as sulfur-containing substances, have the negative impact on the body. They cause mucous membrane irritation of digestive tract, airways and thyroid gland disorder [3, 4, 32].

The purpose of the study is to create salad oils on the basis of composition of rape, cameline, safflower and coriander oil having the health-promoting effect and to study the physiological properties of final products on laboratory animals.

II. Materials and methods

Two samples of salad oils were studied: I – salad oil made of rape (GOST 31759-2012), safflower (GOST 12096-76) and coriander oil (GOST 31791-2017), II – salad oil made of cameline (GOST 10113-62), safflower (GOST 12096-76) and coriander oil (GOST 31791-2017), which make it possible to obtain specific fatty acids and other lipids not typical for traditional vegetable oils or, if present, only in small quantities. The study focused on organoleptic, physical and chemical properties, as well as safety indicators of initial vegetable oils as components for the salad oil. The below state standards (GOSTs) and methods were used to assess the quality of vegetable oils.

Color, flavor, transparency level and a ratio of phosphorus-containing substances were defined in compliance with GOST 5472-50. Qualitative soap test was carried out according to GOST 5480-59. Moisture and volatile substances were defined according to GOST 11812-66. The peroxide number was defined in vegetable oils via titration method in accordance with GOST P 51487-99. The acid number was determined through titration of a fat sample with potassium hydroxide solution. Phenolphthalein served the indicator (GOST P 52110-2003). The color value was defined on the basis of GOST 5477-93 using the Lovibond PFX 995 device. The measurement range made 420-710 nanometers. The results were obtained in iodine units and according to Lovibond RYBN colour scale (red, blue, yellow, neutral). The iodine value in samples was defined in accordance with GOST 5475-69; soap factor in samples – in accordance with GOST 5480-59. The mass fraction of tocopherol was defined by MU 08-47/184 (FR. 1.31.2005.01810) via the HELC method.

Via the modified technique the fatty acids content of oils was placed on a Khromatek-Kristall gas chromatograph. The flame ionization detector was used in the study. Sample preparation and determination of fatty acid content was carried out in accordance with GOST 51483-99. The amino-acid content was defined via ion-exchange chromatography on AAA-881 amino analyzer.

All experiments with white male rats were carried out at V.M. Gorbatov Federal Research Center for Food Systems-RAS taking into account the existing ethical standards and rules in strict compliance with the research protocol and current legal requirements. Biological studies were conducted in two groups of white male rats with initial mass (68±1.9) g (16 animals in each group). The experimental animals were kept on a balanced diet that included the following caloric content: 18% protein (casein), 62% carbohydrates (potato starch) and 20% fat – studied samples of salad oil. Besides, the diets included all necessary mineral substances and the complex water- and lipid soluble vitamins. The specified diets were fed to experimental animals within 10 weeks. During this period, we observed the body height, development and the general condition of animals.

TABLE I. CHARACTERISTICS OF BIOCHEMICAL COMPOSITION OF SALAD OILS

Parameter	Test sample I	Test sample II
Acid value, mg KOH/g	1.19	1.28
Iodine value, g J_2/100g	112	128
Color value, mg J_2	28.1	28.9
Peroxide number, mmol of active oxygen, kg	2.46	2.67
Wax mass fraction, %	0.15	0.12
Saponification value, mg KOH/g	172	178
Moisture and volatile content, %	1.15	1.11
Mass fraction of unsaponification matters, %	0.21	0.28
Tocopherol content, mg/kg:		
α-tocopherol	438.4	303.7
β-tocopherol	217.2	119.3
γ-tocopherol	303.3	289.9
Sulfur content, mg/kg	2.10	3.19

TABLE II. FATTY ACID CONTENT IN THE STUDIED SAMPLES OF SALAD OILS

No. of sample salad oil	Fatty acids						
	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenoic acid	Gadoleic acid	Erucidic acid
Test sample I	7.15	2.28	23.68	47.15	4.68	8.32	0.15
Test sample II	6.62	2.01	23.25	42.36	3.97	9.25	0.09

TABLE III. BIOLOGICAL PARAMETERS

Parameter	Salad oil	
	First sample	*Second sample*
Rat body weight, g, M±m	263 ± 8	273 ± 8
Energy efficiency of a diet, kcal/g of body weight gain	20.7	20.1
Content in blood serum, mg %, M ±m:		
Total lipids	259 ± 10	273 ± 14
Beta-lipoproteins	185 ± 11	166 ± 11
Cholesterol	62 ± 5	82 ± 4
Mass fraction ratio, M±m:		
liver	31.4 ± 1.0	32.7 ± 1.0
kidneys	6.8 ± 0.3	6.9 ± 0.3
spleen	2.2 ± 0.1	2.4 ± 0.3
heart	3.6 ± 0.2	4.1 ± 0.1
Chemical composition of rat organs and tissues:		
total lipids, g	27.0	34.2
total lipids, % (of dry matter)	32.0	38.0
proteins, g	46.7	43.0
proteins, %	55.6	47.8
mineral substances, g	7.7	7.7
% of dry matter	9.2	8.5
Protein-lipid ratio	1.72	1.25
Lipid content in rat liver, % of liver dry matter	21.9	24.3
FEM	1.64	1.42

The results of the study were processed by parametric methods of variation statistics using epy Student's t-test for unrelated populations. The arithmetic average (M), mean square deviation (σ), variation coefficient (V), mean arithmetic average error (m) were defined to check the statistical significance of two samples at significance level $p<0.05$

III. RESULTS AND DISCUSSION

Biochemical parameters and fatty acid content of two samples of salad oils were studied (Tab. 1, 2).

It is found that both groups of rats had a similar palatability ratio of diets, as well as similar body weight gain and hence, almost similar energy efficiency of a diet (Tab. 3).

Upon termination of biological observations, 10 rats were selected from each group to define the lipid fraction of blood serum. Quite similar content of total lipids and beta-lipoproteins was noted. The rats of the II group had higher content of total cholesterol in the blood serum. The differences between groups regarding this parameter were statistically reliable (Tab. 3).

The data on chemical composition of organs and tissues of animals showed that the samples of salad oil had a different influence on the organism of rats. Thus, the rats of the I group accumulated less depot fat and total lipids. The protein content was higher. As a result, they had high protein-lipid ratio – 1.72. Such protein-lipid ratio is typical for animals consuming liquid vegetable oils. The rats of the II group had lower ratio of accumulated basic materials. They had increased lipid content and decreased accumulated protein content thus leading to sharp reduction of protein-lipid ratio (to 1.25). This fact shall be considered as the degradation factor of biological properties of the 2nd sample of salad oil. As for lipid content in a liver, it shall be noted that it was increased for both groups of rats (Tab. 3).

The postmortem examination of organs and tissues of rats demonstrated minor macroscopic changes of digestive tract mucosae and more significant changes resulting in fatty liver of both experimental groups. The study of relative coefficients of vital mass (heart, kidneys, liver, spleen) showed the tendency towards their increase for rats of the II group, and the relative coefficient of the heart mass was even characterized by statistically valid increase ($P<0.05$), which demonstrates a certain negative impact of the 2nd sample of the studied salad oil on the organism of animals.

IV. CONCLUSIONS

The development of compositions of salad oils not containing erucidic acid allows improving and balancing the fatty acid content in relation to polyunsaturated fatty acid ω-3 and ω-6, as well as those having a health-promoting effect. The animals did not have considerable differences in metabolism of fatty acids when fed with a diet of the 1st and the 2nd sample of salad oils, which is confirmed by FEM value (1.64 and 1.42 respectively). However, increase in sulfur content of the studied samples from 2.10 to 3.19 mg/kg leads to the increase in relative vital mass coefficients (heart, kidneys, liver, spleen), which demonstrates a certain negative impact on the organism of animals consuming salad oil containing 3.19 mg/kg of sulfur.

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