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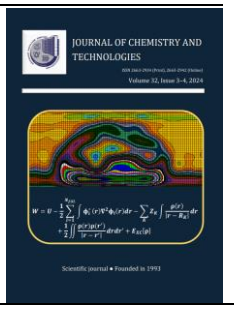

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FATTY ACID COMPOSITION OF THE GERODIETETIC PRODUCT FOR ENTERAL NUTRIOTION

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Abstract

Lipids are one of the main nutrients determining nutritional value. The fatty acid composition of the developed gerodietetic product's for enteral nutrition lipids and its biological effectiveness were researched. The determination of the lipids content was carried out by gravimetric method, Folch's method was applied for their extraction. Fatty acids composition was analysed by gas chromatography method. Identification of fatty acids composition was carried out by comparing the obtained mass spectra with standard ones, their content was calculated by the area of the corresponding peaks. The coefficient of lipids biological significance was calculated as the ratio of eicosapentaenoic and docosahexaenoic acid (DHA) polyunsaturated fatty acids (PUFAs) sum to the mass fraction of total lipids. Based on the conducted research it was found lipids content in the developed product is 11.82±0.13 mass%. PUFAs dominate among them (44.85 mass%). The ratio of polyunsaturated, monounsaturated and saturated fatty acids is 1.00 : 0.52 : 0.67. Linoleic acid predominates on the quantitative composition of product's fatty acids (22.19 mass%). The content of omega-3 fatty acids is 11.84 % of total lipids. The ratio of omega-3 to omega-6 fatty acids is 1.00 : 2.07, corresponds to the norms recommended in emergencies – 2.0 : 1 – 4.0 : 1. The content of omega-3 fatty acids is11.84 mass%. The ratio of omega-3 to omega-6 fatty acids is 2.07 : 1 and corresponds to the norms recommended for people in in emergencies – 2.0 : 1 – 4.0 : 1.The estimated biological significance of the developed product's lipids is 40.4 %. The research results provide an opportunity to state that the developed gerodietetic product's for enteral nutrition fatty acid composition is characterized by rather high nutritional value. It was experimentally confirmed that the developed product is characterized by sufficiently high content of PUFAs, in particular linoleic, α-linolenic, EPA, DHA.
Keywords: lipids; fatty acid composition; products for enteral nutrition; nutritional and biological value; representatives of the older age groups.

ЖИРНОКИСЛОТНИЙ СКЛАД ГЕРОДІЄТИЧНОГО ПРОДУКТУ ДЛЯ ЕНТЕРАЛЬНОГО ХАРЧУВАННЯ

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Анотація

Ліпіди є одним із основних нутрієнтів, що забезпечують харчову цінність. У статті досліджено жирнокислотний склад ліпідної складової розробленого геродієтичного продукту для ентерального харчування, проведено оцінку показників її біологічної ефективності. Визначення вмісту ліпідів проведено гравіметричним методом, для їх екстракції використано метод Фолча. Склад жирних кислот проаналізовано методом газової хроматографії. Ідентифікацію складу жирних кислот здійснювали шляхом порівняння одержаних мас-спектрів зі стандартними, вміст розраховували за площею відповідних піків. Коефіцієнт біологічної значимості ліпідів розраховано як відношення суми ейкозапентаєнової (ЕПК) та докозагексаєнової (ДГК) поліненасичених жирних кислот до масової частки загальних жирів. Встановлено, що вміст ліпідів у розробленому продукті складає 11.82±0.13 мас.%. Серед них домінують поліненасичені жирні кислоти (44.85 мас.%). Співвідношення поліненасичених, мононенасичених і насичених жирних кислот становить 1.00 : 0.52 : 0.67 відповідно. За кількісним вмістом у продукті переважає лінолева кислота (22.19 мас.%). Вміст омега-3 жирних кислот становить 11.84 мас.%. Співвідношення омега-3 і омега-6 жирних кислот складає 1.00 : 2.07 і відповідає нормам, рекомендованим для людей у надзвичайних ситуаціях – 2.0 : 1–4.0 : 1. Коефіцієнт біологічної значимості ліпідів розробленого продукту складає 40.4 %. Результати дослідження жирнокислотного складу ліпідів розробленого геродієтичного продукту для ентерального харчування свідчать про їх досить високу харчову цінність, збалансованість. Експериментально встановлено, що розроблений сухий розчинний виріб характеризується достатньо високим вмістом поліненасичених жирних кислот, зокрема лінолевої, α-ліноленової, ейкозапентаєнової, докозагексаєнової.
Ключові слова: ліпіди; жирнокислотний склад; продукти для ентерального харчування; харчова та біологічна цінність; представники старших вікових груп.

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Introduction

The current global demographic situation can be characterized by a clear trend in the aging of the population. According to the World Health Organization's specialists' data in 2020 the number of people, aged 60 years and older, exceeded level 1 billion. It is forecasted that 2050 this number will be doubled to 2.1 billion (from 12 % to 22 %) [1]. The United Nations officials state that in 2050, the number of persons aged 65 years or older across the world will be twice the number of children under 5 years, almost the same as that of children under age 12 [2]. This global trend is especially relevant for Ukraine, where the number of people, aged 60 and older, exceeded 10 million and is nearly 25 % of the total population [3].

Aging is considered an inevitable physiological process that occurs with the body throughout life. According to generally accepted scientific data [4; 5], it is defined as a complex process that is characterized by a gradual decrease adaptability of organism to the environment's conditions, a decrease, and loss of psychophysiological functions. It is appropriate to note that as a result of this process, there are gradual changes in the state of the body's systems, in particular the digestive, cardiovascular, immune, nervous, musculoskeletal, and its organs. Also, energy imbalances are observed, the productivity and intensity of the metabolic process decrease [5–7]. It has been scientifically established that nutrition, balanced with the physiological needs, can minimize negative processes of age-related changes and improve the quality of life [4; 8; 9].

Nutrition is naturally considered to be one of the main factors that determine a human being's lifestyle and standard of living. Its compliance with the organism's metabolic needs ensures the possibility of maintaining a full-quality life, performing physical and intellectual activities, and being an active member of society in great measure. As a means of ensuring physiological needs and recovery, reducing the effects of negative external and internal factors, nutrition is especially important in emergency situations. In particular, examples of such conditions are cases when the body is subjected to increased psycho-emotional and physical loads, stresses, injuries, diseases, traumas, including somatic. In this regard, the practice of consuming (using) food for special medical purposes is quite common nowadays [10–12].

It should be noted that according to the internationally recognized norms, in particular provisions of Regulation № 609/2013 of the European Parliament and the Council mentioned items of foodstuffs are defined as "food specially processed or formulated and intended for the dietary management of patients, including infants, to be used under medical supervision; it is intended for only or partial feeding of patients with a limited, impaired or disturbed capacity to take, digest, absorb, metabolise or excrete ordinary food or certain nutrients contained therein, or metabolites, or with other medically-determined nutrient requirements, whose dietary management can't be achieved only by modification of the normal diet".

The analysis results of the current state of the food for special medical purposes market indicate that at the international level it is developing quite intensively. This is confirmed by the fact that in 2023 the volume of these products world market exceeded 14 billion US dollars [13]. It was also investigated that according to the specialists' market forecasts [13], the volume of this market segment should exceed 19.5 billion US dollars. USA and the average compound annual growth rate (CAGR) is expected to be near about 5.8 %. At the same time, it is appropriate to note that despite the war and a significant injured people in Ukraine, the national market of the country is slightly developed (it is about 0.1 % of the global market) and is characterized by a low quantity of this assortment group products manufactured by domestic enterprises [14; 15].

One of the types of food for special medical purposes are products for enteral nutrition. These varieties of products, intended for oral consumption or introduction through a nasogastric tube, are focused on ensuring the metabolic needs of the body, correcting and eliminating its disorders, caused by negative external and internal factors [12]. Optimum provision of nutritional needs allows to reduce pathological consequences, increase the body's protective functions, optimize and accelerate its recovery in the process of impact from emergencies, including for representatives of older aging groups. Due to this, products for enteral nutrition are becoming more and more widely spread.

Taking into account the limited assortment of food for special medical purposes in Ukraine and the need to take into account age-related changes in the body during aging process, the gerodietetic product for enteral nutrition was developed [16]. To simplify the conditions of transportation and to extend the period of storage the product is offered

in a dry soluble form. It is provided that preparation for consumption (use) should be done by dissolving a portion of the dry product's mixture (50 g) in prepared boiled water at a temperature of 15–30 °C (200 cm^3 or more according to needs and preferences).

It has been scientifically proven that food lipids provide 2 main physiological functions in the human body: non-specific (energy) and specific. The last one consists in providing essential fatty acids, fat-soluble vitamins, substrate for biosynthesis and building up the cell envelope, adipose tissues of the body [17]. Polyunsaturated omega-3 fatty acids, in particular eicosapentaenoic (EPA) and docosahexaenoic (DHA) fatty acids, are important for organism, especially injured, antioxidant and anti-inflammatory protection [18; 19]. Also they are important for preventing cardiovascular disease [18]. An improper ratio of fatty acids in the diet can lead to various physiological problems, including inflammatory diseases, obesity and cardiovascular disorders. Balanced consumption of fatty acids contributes to the general health improvement and human body well-being. The ability to meet special metabolic needs in optimal fatty acid composition is essential for people in emergencies. In this regard, the content and ratio of fatty acids is an important indicator of biological value. The polyunsaturated fatty acids presence of is considered an indicator of lipid metabolism [17; 20].

The purpose of the research is to identify the fatty acid composition of the lipid component of the developed enteral nutrition product and evaluate its biological effectiveness.

Materials and methods

The object of the research was the developed gerodietetic product for enteral nutrition [16]. It is stipulated that the constituent components of this dry soluble product are (per 100 g): whey protein concentrate WPC-80 (25.00 g), monodisperse maltodextrin (25.00 g), glucose (20.00 g), omega-3 polyunsaturated fatty acids derived from microalgae Ulkenia sp. and presented in casein matrix (the content of omega-3 fatty acids is more than 90 %) (10.80 g), fructose (10.00 g), dietary fiber (5.34 g), l-glutamine (2.00 g), l-methionine (0.50 g), l-tryptophan (0.30 g), ginseng root extract (0.50 g), ascorbic acid (0.25 g), l-tyrosine (0.10 g), glucosamine hydrochloride (0.10 g), creamery calcium (41 mg), coenzyme Q10 (30 mg), magnesium hydrophosphate (22 mg), β–carotene (8 mg), calciferol (5 mg), riboflavin (2 mg), pyridoxine (2 mg).

The product for enteral nutrition "Peptamen" manufactured by the company "Nestle" (Switzerland) was chosen as a control sample. It is established that according to the information presented on the labelling the control product contains: maltodextrins, enzymatically hydrolyzed whey and soy proteins, sucrose, fructose, middle-chain triglycerides, potato starch, soy oil and lecithin, lime carbonate, sodium phosphate, magnesium chloride, choline bitartrate, flavour identical to natural (vanillin), potassium phosphate, sodium ascorbate, magnesium citrate, l-carnitine, taurine, retinol acetate, zinc sulfate, pyridoxine hydrochloride, thiamine, riboflavin, niacin, folic acid.

Sampling and preparation of products samples for research were provided according with the provisions of the standard ISO 707:2008 [21].

Determination of the content of total lipids from samples was carried out by the gravimetric method [22]. Folch's method [23] was applied for the extraction of total lipids from products samples. Products samples were homogenized in a chloroform-methanol mixture (2 : 1, by volume), centrifuged in a refrigerated centrifuge CM-50M (Latvia) to separate the water-soluble and organic phases. After that, the organic phase was separated, the chloroform was evaporated using a mini-evaporator. The amount of total lipids in each sample was expressed as a percentage of dry weight.

The composition ratio of fatty acids was analysed using the method of gas chromatography [24; 25] in a gas chromatograph HP-6890 (Great Britain) with the mass-selective detector HP-5972. Also, non-polar 30 m × 0.25 mm × 0.25 μm capillary column HP-5MS (5% Diphenyl) was used. Gas chromatograph operating parameters were following: Helium was used as a carrier gas, its flow rate – 1 cm^3/min, sample volume – 1 μl, evaporator temperature – 250 °C, its initial temperature – 45 °C, heating rate – 10 °C/min, final temperature – 280 °C, holding time at 280 °C – 5 min. The parameters of the detector were as follows: the temperature of the ion source and the interface line was 280 °C. The identification of fatty acids was carried out by comparison with the corresponding mass spectra of standard ones, using stated in the electronic databases "Wiley 138" and "Nist 02 Spectra Lib" [26]. Analysed fatty acids were expressed as a percentage of total quantity basing on the area of the corresponding peaks on the chromatogram.

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The biological significance of products lipids was calculated as the ratio of the sum of eicosapentaenoic acid (EPA) and docosahexaenoic (DHA) PUFAs to the mass fraction of total fats [27].

The repeatability of the samples was fivefold, of the studies – triple. Statistical analyses were performed using MATLAB software (R2023b v23.2.0). The significance of the difference in mean values was assessed using the Student's parametric t-test. The difference is considered reliable at $p \leq 0.05$.

Results and their discussion

Based on the results of the research, it was established that content of lipids in the developed product is 11.82±0.13 g/100 g, while, the value of the corresponding indicator for the control sample is 16.79±0.15. It shows that lipids content in the control product is higher by almost 4.97 g/100 g (29.6 %). It is explained by the fact that the developed product was intended to meet the metabolic needs of persons in the older age group.

The qualitative and quantitative composition of fatty acids is reasonably considered to be important indicators that allow assessing the value of the lipid component of food products. Taking this into account, the fatty acid composition of lipids of products for enteral nutrition was researched. The results are presented in Table 1.

Table 1

Fatty acid composition of lipids of dry soluble products for enteral nutrition

P ≥ 0.95; n = 15

Fatty acids	Mass fraction of fatty acids, % of total lipids	
	Control sample	Developed product
Saturated fatty acids (SFAs)		
3:0: Propionic acid	0.060±0.005	0.040±0.005
9:0: Pelargonic acid	0.340±0.010	traces
10:0: Capric acid	0.040±0.005	0.020±0.005
11:0: Undecylic acid	0.620±0.050	0.280±0.010
12:0: Lauric acid	0.070±0.005	0.050±0.005
13:0: Tridecylic acid	0.320±0.010	traces
14:0: Myristic acid	4.760±0.020	8.010±0.050
15:0: Pentadecylic acid	0.820±0.020	0.210±0.010
16:0: Palmitic acid	18.410±0.500	17.710±0.460
17:0: Margaric acid	0.620±0.020	0.110±0.010
18:0: Stearic acid	5.420±0.100	2.610±0.050
20:0: Arachidic acid	0.340±0.020	0.240±0.010
21.0: Heneicosanoicic acid	0.280±0.020	0.210±0.010
22:0: Behenic acid	0.810±0.020	0.310±0.010
24:0: Lignoceric acid	1.310±0.020	0.360±0.010
Total SFAs	34.220±0.825	30.160±0.645
Monounsaturated fatty acids (MUFAs)		
12:1: Lauroleic acid	0.210±0.010	traces
14:1: Myristoleic acid	0.520±0.010	0.230±0.010
16:1: Palmitoleic acid	3.740±0.100	6.450±0.500
18:1: Oleic acid	18.540±0.800	16.360±0.650
20:1: Gondoic acid	0.180±0.010	0.260±0.010
22:1: Erucic acid	0.210±0.010	0.130±0.010
Total MUFA	23.600±0.940	23.430±1.180
Polyunsaturated fatty acids (PUFAs)		
16:2: Hexadienoic acid	0.670±0.050	0.340±0.010
16:3: Hexadecatrienoic acid	2.580±0.050	6.720±0.100
18:2: Linoleic acid	25.720±0.500	22.190±0.500
18:3: α -Linolenic acid	4.540±0.100	5.430±0.100
18:4: Stearidonic acid	1.940±0.020	1.230±0.020
20:4: Arachidonic acid	0.950±0.050	1.780±0.020
20:5: Eicosapentaenoic acid (EPA)	1.540±0.030	2.740±0.500
22:2: Docosadienoic acid	0.380±0.020	0.220±0.010
22:3: Docosatrienoic acid	0.280±0.010	0.200±0.010
22:4: Docosatetraenoic (adrenic) acid	0.170±0.010	0.330±0.050
22:5: Docosapentaenoic acid (DPA)	0.640±0.010	1.630±0.050
22:6: Docosahexaenoic acid (DHA)	1.140±0.050	2.040±0.050
Total PUFAs	40.750±0.900	44.850±1.420
Unidentified	1.430±0.040	1.560±0.050
Total	100.00	100.00

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The results of the research of the fatty acid composition of the developed product indicate that PUFAs are dominating among presented fatty acids (44.85 mass%). Their quantity in the developed product is 9% higher compared to the control sample. This is explained by a more balanced approach to meeting the specific needs of older aging groups representatives in emergency situations.

Linoleic acid (18 : 2) prevails among PUFAs, presented in the composition of both products: in the developed product its content is 22.19 mass%, in the control it is 25.72 mass%. Such content of this nutrient is justified by its important value for plastic processes, regeneration. It is worth noting that to ensure the proper conditions for recovery. α-linolenic fatty acid is present in both samples. In particular, its content in the developed product is 16.4 % higher than in control one.

According to generally accepted norms, the biological value and physiological efficiency of lipids are significantly determined by the ratio of fatty acids, their balance. In practice, a corresponding analysis was conducted to evaluate these criteria. The obtained results are presented in Table 2.

Table 2

Indexes of biological value of dry soluble products for enteral nutrition lipids

Indexes of lipids biological value	Control sample	Developed product
Amount of omega-3 fatty acids, % of total lipids	7.86	11.84
Amount of omega-6 fatty acids, % of total lipids	27.22	24.52
PUFAs : MUFAs : SFAs ratio	1.00: 0.60 : 0.84	1.00: 0.52 : 0.67
The ratio of omega-3 to omega-6 fatty acids	1 : 3.46	1 : 2,07
The ratio of linoleic acid to α-linolenic acid	1 : 5.67	1 : 4.09

On the basis of the data submitted in table 2, it was established that the nutritional value of the lipids of the studied products is rather high. This is confirmed by rather high content of omega-3 and omega-6 fatty acids in the products. In the developed product the content of omega-3 fatty acids is 33.6% higher than in control one. At the same time the content of omega-6 fatty acids is almost 10% lower. The ratio of these acids in the developed dry product is 1 : 2.07 while in the control one – 1 : 3.46. For both analysed products, the ratio of the studied nutrients corresponds to the norms recommended people in critical conditions, in particular during inflammatory reaction – 1 : 2 – 1 : 4 [20; 28].

Based on the obtained results about the ratio of the sum of eicosapentaenoic acid (EPA) and docosahexaenoic (DHA) PUFAs (4.780 mass%) to the mass fraction of total fats (11.82 mass%), it was established that the biological significance of the developed product's lipids is 40.4 %. At the same time, the corresponding value of the control sample is about 15.9 % (almost 2.5 times lower). This is ensured by the fact that omega-3 PUFAs in the casein matrix are used as raw materials to provide the lipid component of the developed product.

Conclusions

The obtained results of the research data of the fatty acid composition of the developed gerodietetic product's lipid component indicate that it is characterized by sufficiently high nutritional value, balance and compliance with specific needs. It was experimentally established that the developed dry soluble product is characterized by a sufficiently high content of omega-3 and omega-6 PUFAs (α-linolenic – 5.43 mass%, eicosapentaenoic – 2.74 mass%, docosahexaenoic – 2.04 mass%, linoleic – 22.19 mass%), as well as oleic fatty acid (16.36 mas%). This will contribute to the proper digestibility of the product, its usage for the recovery of damaged body's areas, the provision of plastic and energy needs of the body, taking into account the specifics of metabolism.

The prospects for further research are preclinical and clinical trials of the physiological effectiveness of the developed gerodietetic products for enteral nutrition consumption. This will make it possible to determine the practical level of meeting the needs of the elder age group representatives in emergencies, in particular during treating somatic trauma and diseases, further rehabilitation.

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