AVALIAÇÃO DE IMPACTO DE CORRETORES BIOLÓGICOS ALIMENTARES NA EFICIÊNCIA ENERGÉTICA DO ESTADO NUTRICIONAL**IMPACT ASSESSMENT OF ALIMENTARY BIOLOGICAL CORRECTORS ON THE ENERGY EFFICIENCY OF NUTRITIONAL STATUS****ОЦЕНКА ВЛИЯНИЯ АЛИМЕНТАРНЫХ БИОКОРРЕКТОРОВ НА ЭНЕРГОЭФФЕКТИВНОСТЬ ПИЩЕВОГО СТАТУСА**

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RESUMO

O funcionamento eficaz de todos os sistemas do corpo é amplamente determinado por uma série de substâncias essenciais que atuam como ativadores de reações metabólicas. Sua deficiência na dieta leva a violações da homeostase da natureza alimentar, que é exacerbada por fatores ambientais, sociais e econômicos. O presente estudo teve como objetivo comparar as propriedades anti-hipoxêmicas de nutrientes de origem vegetal e animal, seu impacto nos parâmetros respiratórios e de transporte das trocas gasosas, como critérios para o balanço energético do organismo, bem como a avaliação do fator probiótico na melhoria das propriedades anti-hipoxêmicas das substâncias biologicamente ativas direcionadas. O aumento na eficiência das trocas gasosas foi avaliado a partir do exemplo de alunos e professores de uma universidade de engenharia com idades de 16 a 65 anos no consumo diário de produtos alimentícios com propriedades biocorretivas conhecidas: óleo de gérmen de trigo (WGO), farelo de óleo de gérmen de trigo (WGOM), óleo de peixe de tecido concentrado (CTFO) e suas combinações com a biomassa do consórcio de bactérias lacto e bífidas. A mudança da eficiência energética do estado nutricional foi avaliada a partir da análise da concentração de dióxido de carbono (CO₂) e oxigênio (O₂) na mistura ar exalada e do nível de hemoglobina (SpO₂). Seus valores foram registrados antes e após o consumo diário dos produtos testados por 30 dias. A avaliação dos valores médios dos parâmetros em todas as faixas etárias demonstrou que o anti-hipoxêmico mais eficaz foi a farinha de óleo de gérmen de trigo. A combinação de biocorretores sob investigação com formas ativas de microrganismos probióticos fornece um efeito anti-hipoxêmico mais ativo para todos os produtos sob investigação em todas as idades. Os dados obtidos permitem afirmar a possibilidade de um efeito alimentar ativo sobre a eficiência das trocas gasosas, comprovar as propriedades anti-hipoxia do WGO, WGOM e CTFO, bem como o efeito sinérgico de sua combinação com microrganismos probióticos na forma ativa.

Palavras-chave: *biocorretores, metabolismo energético, oxigenação, hemoglobina, microrganismos probióticos*

ABSTRACT

The effective functioning of all body systems is mostly determined by many essential substances that act as activators of metabolic reactions. Their diet deficiency leads to violations of alimentary nature homeostasis, exacerbated by environmental, social, and economic factors. This study aimed to compare antihypoxant properties nutrients of the vegetable and animal origin, their impact on respiratory and transport parameters of gas exchange, as criteria for the energy balance of the body, and the assessment of probiotic factor in improving the antihypoxant properties of targeted biologically active substances. The increase in the efficiency of gas exchange was evaluated on the example of students and teachers of an engineering university at ages from 16 to 65 in daily consumption of food products with known biocorrective properties: wheat germ oil (WGO), wheat germ oil meal (WGOM), concentrated tissue fish oil (CTFO) and their combinations with the biomass of the lacto- and Bifidus bacteria consortium. The change of energy efficiency of the nutritional status was assessed based on the analysis of the carbon dioxide (CO₂) and oxygen (O₂) concentration in the exhaled gas-air mixture and the level of hemoglobin (SpO₂). Their values were recorded before and after the daily

consumption of the tested products for 30 days. The average values of parameters in all age groups have demonstrated that the most effective antihypoxant is the wheat germ oil meal. A combination of biocorrectors under investigation with active forms of probiotic microorganisms provides a more active antihypoxant effect for all products under investigation in all age groups. The obtained data make it possible to state the possibility of an operational alimentary impact on gas exchange efficiency and prove the antihypoxant properties of WGO, WGOM, CTFO, and the synergetic effect of their combination with probiotic microorganisms in the active form.

Keywords: *biocorrectors, energy metabolism, oxygenation, hemoglobin, probiotic microorganisms*

АННОТАЦИЯ

Эффективное функционирование всех систем организма во многом определяется рядом эссенциальных веществ, выполняющих роль активаторов обменных реакций. Их недостаток в рационе питания приводит к нарушениям гомеостаза алиментарной природы, что усугубляется экологическими, социальными и экономическими факторами. Целью работы является сравнительное исследование антигипоксантных нутриентов растительного и животного происхождения и их влияния на респираторные и транспортные показатели газообмена на примере студентов и преподавателей ВУЗа, как критерии энергетического баланса организма, а также оценка пробиотического фактора в повышении антигипоксантных свойств целевых биологически активных веществ. Оценку повышения эффективности газообмена проводили на примере студентов и преподавателей инженерного ВУЗа в возрасте от 16 до 65 лет при ежедневном употреблении пищевых продуктов с известными биокорректирующими свойствами: масла из зародышей пшеницы (МЗП), муки из жмыха зародышей пшеницы (МЖЗП), концентрированного тканевого рыбного жира (КТРЖ) и их комбинаций с биомассой консорциума лакто- и бифидобактерий. Изменение энергоэффективности пищевого статуса оценивали на основе анализа концентрации углекислого газа (CO_2) и кислорода (O_2) в выдыхаемой газовой смеси и уровня оксигенации гемоглобина (SpO_2). Значения данных показателей фиксировали до и после ежедневного употребления исследуемых продуктов в течение 30 дней. Оценка средних значений показателей во всех возрастных группах показала, что наиболее эффективным антигипоксантом является мука из жмыха зародышей пшеницы. Совмещение употребления исследуемых биокорректоров с пробиотическими микроорганизмами в активной форме обеспечивает более значимый антигипоксантный эффект во всех возрастных группах. Полученные данные позволяют констатировать возможность активного алиментарного воздействия на эффективность газообмена, доказывают антигипоксантные свойства МЗП, ЖЗП, КТРЖ, а также синергетический эффект их комбинирования с пробиотическими микроорганизмами в активной форме.

Ключевые слова: *биокорректоры, энергетический обмен, оксигенация, гемоглобин, пробиотические микроорганизмы*

1. INTRODUCTION:

Alimentary technologies of biocorrection of the nutritional status and pathophysiological states of the human body require fundamental and applied research of medical and biological assessment of new sources of food and ingredients. The introduction of innovative physical-chemical, bio- and nanotechnologies for producing highly effective food products of the biocorrective action is needed (Eamonn, 2019; Vernerey *et al.*, 2019; Rodionova *et al.*, 2019d; Fujimura *et al.*, 2010).

In the function of alimentary biocorrectors, dietary supplements have been investigated such as "Vitazar" wheat germ oil (WGO), "Vitazar" wheat germ oil meal (WGOM), "Econol" cryo-concentrated tissue fish oil (CTFO), and "Biomatrix" activated consortium of lacto and bifidus bacteria, which has a composition of *Str.*

thermophilus, *L. Casei subsp. Rhamnosus*, *L. acidophilus*, *L. plantarum*, *L. fermentum*, *B. bifidum*, *B. longum*, *B. adolescentis* in the concentration of milk-based active cells of at least 10^9 CFU/g (Rodionova *et al.*, 2019; Daliri and Lee, 2015).

Biocorrective properties of WGO are contingent upon the high content of vitamins A, D, E, polyunsaturated fatty acids, octacosanol and are confirmed by extensive clinical investigations of therapy for various diseases such as cardiovascular, gastroenterological, diabetes, hepatitis, infertility, burn, and wound injuries (Shpagina, 2008a; Shpagina, 2007; Poljsak, 2011); (Shpagina, 2008b); (Akool, 2019); (Juárez-López *et al.*, 2013); (Lepretti *et al.*, 2018); (Simopoulos, 2002); (Safarinejad *et al.*, 2010); (Ferreira *et al.*, 2012); (Dong, 2018); (Harris, 2008).

A by-product of WGO manufacturing is a

protein-carbohydrate component of the germ (mill cake) with a residual oil content of 6-8%, as determined in the monograph (Vishnyakov and Vlasov, 2011), registered as flour "Vitazar" biologically active dietary supplement (Vishnyakov and Vlasov, 2011). The residual lipid fraction in wheat germ oil meal (WGOM) is identical in chemical composition to the pressed oil and hypothetically preserves its active biological properties (Vishnyakov *et al.*, 2018; Rodionova and Alekseeva, 2015). Besides, WGOM contains up to 30% of the full-value protein in amino acid composition, up to 30% of carbohydrates represented by pentosans, mono-, di-, oligo polysaccharides. WGOM contains significant amounts of vitamins B1, B2, B6, PP, E, K, macro- and micronutrient elements such as Zn, Mn, Mg, Ca, K, Fe, Se, P, as has been demonstrated in previous papers (Shpagina, 2008b).

Biologically active dietary supplement "Econol" represents cryo- concentrated tissue fish oil (CTFO). It is a valuable active bioregulator of metabolic processes. It is obtained because of physical-chemical actions on the fish raw material, making it possible to destroy the cell membrane with subsequent mechanical separation of the lipid fraction from the rest of the processed raw materials. CTFO is a source of polyunsaturated fatty acids (PUFAs) such as ω -3 eicosapentaenoic and docosahexaenoic acids, vitamins A, D, and E. Clinical investigations conducted in many countries have indicated that lipids of marine organisms are an effective remedy for lipid metabolism disorders in the human body, which prevent cardiovascular diseases, hypercoagulability, as has been demonstrated in papers (Isaev and Simonenko, 2016; Isaev *et al.*, 2015; Isaev *et al.*, 2000; Kerry *et al.*, 2018).

Bio-correcting properties of probiotic microorganisms include trophic and energy supply of the macroorganism, energy supply of the epithelium, immune system stimulation, formation of immunoglobulins, regulation of intestinal peristalsis, participation in regulation, differentiation, and regeneration of the intestinal epithelium, provision of cytoprotection, detoxication, excretion of endo and exogenous toxic compounds, mutagen destruction, activation of drug compounds, the formation of signal molecules (neuro and transmitters), maintenance of ionic, physical and chemical parameters of homeostasis of the juxta-epithelial zone, the supply of substrates for lipo and glucogenesis (Kerry *et al.*, 2018; Banan-Mwine *et al.*, 2015;

Valdovinos-Garcia *et al.*, 2018; Guo *et al.*, 2011; Lee *et al.*, 2009; Bluher *et al.*, 2001).

This study aimed to compare antihypoxant properties nutrients of the vegetable (WGO, WGOM) and animal (CTFO) origin, their impact on respiratory and transport parameters of gas exchange on the example of university students and teachers, as criteria for the energy balance of the body, as well as the assessment of probiotic factor in improving the antihypoxant properties of targeted biologically active substances.

2. MATERIALS AND METHODS:

2.1. Samples

The experimental research objects were WGO contained 180-200 mg/100 g of vitamin E, 1.5-8.0 mg/100 g of polycosanol, and 60 g/100 g of PUFA (produced by PULAT LTD, the Russian Federation). WGOM contained 30-35 g/100 g of protein, 3-4 g/100 g of PUFA, 45-47 g/100 g of digestible carbohydrates, 18-26 g/100 g of dietary fibers 25-30 mg/100 g of vitamin E (produced by PULAT LTD, the Russian Federation). CTFO contained 6.60 mg/100 g of vitamin A, 100 mg/100 g of vitamin D, 100 mg/100 g of vitamin E; PUFA content was not less than 25 g/100 g (production of TRINITA LTD academic research and production enterprise, the Russian Federation). The concentration of active cells has characterized the biomass of "Biomatrix" consortium of lacto- and bifidobacteria (*Streptococcus thermophilus*, *Casei subspecies Rhamnosus*, *L. acidophilus*, *L. plantarum*, *L. fermentum*, *B. bifidum*, *B. longum*, *B. adolescentis*), not less than 109 CFU/ml (production of Lactinal LTD, the Russian Federation).

2.2. Analysis

In the function of recorded parameters – indicators of changes in energy metabolism efficiency at the time of nutritional intervention of the abovementioned biocorrectors and their combinations with probiotics - changes in the concentration of oxygen (O₂) and carbon dioxide (CO₂) in the exhaled gas-air mixture and the level of oxygenation of blood hemoglobin (SpO₂) have been investigated. To investigate the concentration of O₂ and CO₂ in the exhaled gas-air mixture, we used the TESTO-310 gas analyzer of TESTO RUS LTD production. The sensitivity of the device for O₂ was characterized by the concentration range of 0-21 % vol.,

resolution of 0.01 vol. %, error of ± 0.2 vol. %. The sensitivity of the device for CO₂ was characterized by the concentration range of 0-100 vol. %, resolution of 0.01 vol. %, and error of ± 0.2 vol. %. As well as MDG-1201capnograph was used with the measurement range for CO₂ concentration of 0-13 vol. % and error of ± 0.3 %.

2.3. Setting up an experiment

There was no forced ventilation and air conditioning in the room (laboratory and lecture hall), the room was not aerated; factors that significantly affect the initial oxygen content in the room have been minimized. The concentration of O₂ and CO₂ in the exhaled gas-air mixture was determined immediately after 90 minutes of classroom sessions. The motion activity of all students and teachers was the same and minimal. Before the experimental investigation, the patient was at rest for 10 minutes. To obtain stable and more significant results in terms of CO₂ content, the air intake into the lungs was accompanied by exhalation delay for at least 15-20 seconds, until stabilization of parameters of O₂ and CO₂ concentrations on the device display (Vishnyakov *et al.*, 2020).

Measurement of O₂ content in blood was carried out non-invasively, using ChoiseMmedMD 300C21C pulse oximeter. The saturation level was calculated as a ratio of the amount of HbO₂ to the total amount of hemoglobin, expressed as a percentage by the formula:

$$SpO_2 = \frac{HbO_2}{(HbO_2 + Hb)} \times 100\%$$

The respiratory quotient (RQ) was calculated as the ratio of concentrations of CO₂ excreted from the body to O₂ absorbed at the same time. Measurement of each of the investigated parameters was carried out in a three-fold repetition for all students and teachers under investigation with the subsequent obtaining of arithmetic mean values (Davis *et al.*, 2019; Rattaray *et al.*, 2014; Lawal *et al.*, 2017; Zaric *et al.*, 2014). The reliability assessment of the obtained arithmetic mean values of the investigated parameters was carried out by the non-parametric Mann-Whitney U-test (Nakagawa and Cuthill, 2007), according to the monograph (Grachev and Plaksin, 2005).

2.4. Experimental groups

In the course of the research, the volunteer patients were divided into four groups.

The first group consumed 3.5 g of WGO, the second group consumed WGOM in an amount that provided delivery of 3.5 g of oil in the form of a culinary product, which corresponded to 50 g of mill cake. The third and fourth groups consumed probiotic emulsion containing 3.5 g of WGO or 6.5 g of CTFO in combination with 10 g of lacto and bifidobacteria biomass. The stability of the emulsions was at least 70-75%, due to the high exo polysaccharide activity of probiotic biomass. These food forms were consumed by volunteers regardless of meals, without correction of the main diet. The duration of the experimental investigation was 30 days. At the beginning and the end of the biocorrectors intake, the parameters under investigation were monitored. On the day of sampling, the biocorrectors under investigation were not given to the research subjects; the time interval between the intake of the tested products and sampling was at least 24 hours.

Four experimental groups of research subjects voluntarily included men and women at the ages of 16 to 65 years old. They were students and teachers of Voronezh State University of Engineering Technologies, who spend at least 6 hours daily in the same conditions in the university's premises. The exclusion criteria were smoking, pregnancy, and chronic illnesses; these have been applied in the monograph (Vishnyakov *et al.*, 2020). All research subjects had not previously consumed the biocorrectors under study. To exclude changes related to the seasonality of nutrition and physical activity, the study was conducted in the fall period. Before starting the experimental studies, each volunteer has documented his consent to be included in the experimental group.

The number of experimental groups was 70, 36, 58, and 51 people respectively; the number of control groups that did not consume the products under investigation was the same (Table 1) as has been described in the monograph (Vishnyakov *et al.*, 2020).

3. RESULTS AND DISCUSSION:

Assessment of O₂ and CO₂ concentrations in the exhaled gas-air mixture in all age groups has demonstrated that the most effective antihypoxant is WGOM. The increase of the SpO₂ level by 0.83%, the increase of CO₂ level by 0.44%, and the decrease of O₂ concentrations by 0.36% in the exhaled gas-air mixture have been found on average all age groups. When taking WGO, the increase of the

SpO₂ level amounted to 0.77%, the increase of CO₂ level in the exhaled gas-air mixture amounted to 0.17%, the decrease of O₂ concentration in the exhaled gas-air mixture amounted to 0.21% also on the average for all age groups. The results are presented in Figures 1-6.

When comparing the results obtained with the age of patients, it has been found that in the first age group, the increase of SpO₂ level amounted to 0.91%, the increase of CO₂ concentration and the decrease of O₂ concentration in the exhaled gas-air mixture amounted to 0.38% and 0.29% respectively. In the second age group, the SpO₂ level increased by 0.82%, the concentration of CO₂ in the exhaled gas-air mixture increased by 0.27%, the decrease of O₂ concentration amounted to 0.25%. In the third age group, the SpO₂ level increased by 0.59%; simultaneously, the concentration of CO₂ increased by 0.39%, and the O₂ level decreased by 0.31% in the exhaled gas-air mixture (Figures 2, 3).

It is known that a 1% decrease in SpO₂ level is observed when the partial oxygen pressure decreases by 20% or corresponds to the research subject's rise to the height of 1000 m above sea level (Anderson and Hlastala, 2007). The increase of SpO₂ level within prescribed limits testifies to the rise of blood transport function, which is essential in ensuring the body performance as a whole (Popovsky and Korot'ko, 2003; Nikolic and Vranic, 2006; Akhem *et al.*, 1989). Found changes of the investigated parameters testify to the shift of the active reaction of blood to the alkaline side, which occurs in the pulmonary capillaries because of the transition of CO₂ in alveolar air (Cornack *et al.*, 1957). The higher the concentration of CO₂ in exhaled air, the more significant the shift of reaction to the alkaline side, the lower the probability of forming "strand coins" of red blood cells, and higher efficiency of O₂ transport (Birben *et al.*, 2012). The reliability of the presented data is confirmed by Mann-Whitney U-test values (Table 2). RQ's value was increased by 1.8% when WGO was taken and by 2.4% when WGOM was taken within 30 days. The increase in this parameter's values in the 1st, 2nd, and 3rd age groups when taking the biocorrectors under investigation amounted to 1.8%, 2.0%, and 1.7%, respectively.

The conducted analysis of the effect of WGO and WGOM, containing the same amount of target biologically active substance (BAS) such as the lipid fraction of wheat germ, demonstrated

that these food products can be attributed to the alimentary factors of biocorrective action, providing restoration of the equilibrium state of the body systems responsible for energy metabolism for age groups from 18 to 65 years. By the example of the biocorrectors under investigation which have, along with the identical concentration of target BAS the different composition of accompanying substances, possibly also having biocorrective properties (Cui *et al.*, 2014), the possibility of a fundamentally new integral approach to the assessment of biological activity of food objects of different nature and complex composition has been proved. WGOM biocorrector, containing a wider range of potentially useful nutrients such as water-soluble vitamins, prebiotics, proteins, and mineral elements, has also demonstrated the higher effectiveness.

The hypothesis of the possibility of increasing the efficiency of target biologically active substances by their combination with probiotic microorganisms made it possible to proceed to the next stage of the investigation described in papers (Isaev and Simonenko, 2015; Isaev *et al.*, 2015; Isaev *et al.*, 2000) – the comparative assessment of biocorrective effect of probiotic emulsions with WGO and CTFO inclusion.

It has been experimentally demonstrated that the combination of consumption of biocorrectors under investigation with the inclusion of probiotic microorganisms is specific for each biocorrector under investigation (Figure 4). Probiotic emulsion with CTFO inclusion demonstrated a more pronounced effect on the increase of CO₂ concentration in the exhaled gas-air mixture and increase of SpO₂ in comparison with the emulsion containing WGO. When probiotic emulsion with WGO and CTFO was taken, the SpO₂ level has increased by 0.85% and 0.90%, respectively, and the concentration of CO₂ in exhaled air has decreased by 0.33% and 0.35%, respectively.

The results illustrate the dependence between the age of patients and the antihypoxant effect achieved by consuming the considered probiotic forms. In the first age group, an increase of SpO₂ level by 0.96% and CO₂ concentration in the exhaled gas-air mixture by 0.29% have been found. In the second group, the SpO₂ level has increased by 0.90%, and the value of CO₂ concentration in the exhaled gas-air mixture has increased by 0.34%. In the third group, the SpO₂ level has increased by 0.69%, and in the exhaled gas-air mixture, the CO₂ level has increased by

0.28% (Figures 5, 6).

The results of experimental investigations on the intake of probiotic emulsion with WGO inclusion make it possible to state a more pronounced increase of SpO₂ level by 0.08% and decrease of CO₂ concentration in exhaled air by 0.16% in comparison with effect from WGO intake. Following the calculated Mann-Whitney U-test values, it has been found that the revealed differences in the arithmetic mean of the investigated parameters are reliable (Table 3).

When comparing the medical and biological indications for WGO, WGOM, and CTFO application in therapy for various diseases and experimentally proved positive correction of the food status energy efficiency, a stable correlation is observed according to works (Shpagina, 2008a; Shpagina, 2007; Shpagina, 2008b; Vishnyakov and Vlasov, 2011; Isaev and Simonenko, 2016; Isaev *et al.*, 2015; Isaev *et al.*, 2000; Vishnyakov *et al.*, 2020; Nikolic *et al.*, 2004; Szebeni and Toth, 1986; Rifkind *et al.*, 2003).

4. CONCLUSIONS:

It can be concluded that there was increase in the level of oxygenation of hemoglobin in the blood, an increase in the level of carbon dioxide, and a decrease in the concentration of oxygen in the exhaled gas mixture in all age groups when adding WGO, WGOM, and CTFO to the main diet. The most effective antihypoxant was WGOM. Less pronounced changes in the investigated parameters have been registered when taking WGO. Determined that a combination of the consumption of biocorrectors under investigation with probiotic microorganisms in active form provides a more significant antihypoxant effect in all age groups. The role of alimentary factors in increasing the efficiency of the most important energy functions of the organism regardless of sex and age, which naturally leads to an increase of the organism resistance to external and internal effects, is salient. This is especially relevant for students and teachers of a technical university in closed premises with low mobility and mental stress.

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Table 1. Composition and size of experimental groups

Name of biocorrector	Age of patients, years old			Total
	16-24	25-44	45-65	
WGO	35	18	17	70
WGOM	24	5	7	36
Probiotic emulsion with WGO inclusion	28	20	10	58
Probiotic emulsion with CTFO inclusion	21	20	10	51

Table 2. Calculated Mann-Whitney U-test values

After the course of WGO administration		After the course of WGOM administration	
SpO ₂ , %	O ₂ /CO ₂ , %	SpO ₂ , %	O ₂ /CO ₂ , %
1st group, Ucr=113.0 (30.0)			
92.5	94.0/97.5	19.5	22.5/23.5
2nd group, Ucr=99.0 (5.0)			
71.5	78.5/73.5	2.5	3.0/4.0
3rd group, Ucr=87.0 (8.0)			
72.0	64.0/68.0	4.5	6.0/3.5

Table 3. Calculated Mann-Whitney U-test values

After the course of probiotic emulsion with WGO inclusion administration		After the course of probiotic emulsion with CTFO inclusion administration	
SpO ₂ , %	CO ₂ , %	SpO ₂ , %	CO ₂ , %
1st group. Ucr=23.0 (23.0)			
16.5	14.0	17.5	16.0
2nd group. Ucr=23.0 (23.0)			
15.0	16.5	19.7	18.0
3rd group. Ucr=23.0 (23.0)			
17.0	18.5	18.0	17.5

a

b

c

Figure 1. Concentration of SpO₂, % in blood (a); concentration O₂, % (b) and CO₂, % (c) in exhaled gas-air mixture. 1 – before WGO intake; 2 – after 30 days of WGO intake; 3 – the control group (during the whole period); 4 – before WGOM intake; 5 – after 30 days of WGOM intake; 6 – the control group (during the whole period)

a

b

c

Figure 2. Concentration of SpO₂, % in the blood (a); concentration O₂, % (b) and CO₂, % (c) in the exhaled gas-air mixture. 1, 4, 7– before WGO intake in the 1st, 2nd, and 3rd age groups; 2, 5, 8– after 30 days of WGO intake in the 1st, 2nd, and 3rd age groups; 3, 6, 9 – the control group (during the whole period)

a

b

c

Figure 3. Concentration of SpO₂, % in the blood (a); concentration O₂, % (b) and CO₂, % (c) in the exhaled gas-air mixture. 1, 4, 7– before WGOM intake in the 1st, 2nd, and 3rd age groups; 2, 5, 8– after 30 days of WGOM intake in the 1st, 2nd, and 3rd age groups; 3, 6, 9 – the control group (during the whole period)

a

b

Figure 4. Concentration of SpO₂, % in the blood (a) and CO₂, % in the exhaled gas-air mixture (b)
 1 – before intake of probiotic emulsion with WGO inclusion; 2 – after 30 days of intake of probiotic emulsion with WGO inclusion; 3 – the control group; 4 – before intake of probiotic emulsion with CTFO inclusion; 5 – after 30 days of intake of probiotic emulsion with CTFO inclusion; 6 – the control group (during the whole period)

a

b

Figure 5. Concentration of SpO₂, % in the blood (a) and CO₂, % in the exhaled gas-air mixture (b) 1, 4, 7– before intake of probiotic emulsion with WGO inclusion in the 1st, 2nd and 3rd age groups; 2, 5, 8– after 30 days of intake of probiotic emulsion with WGO inclusion in the 1st, 2nd, and 3rd age groups; 3, 6, 9– the control group (during the whole period)

Figure 6. Concentration of SpO₂, % in the blood (a) and CO₂, % in the exhaled gas-air mixture (b) 1, 4, 7– before intake of probiotic emulsion with CTFO inclusion in the 1st, 2nd and 3rd age groups; 2, 5, 8– after 30 days of intake of probiotic emulsion with CTFO inclusion in the 1st, 2nd, and 3rd age groups; 3, 6, 9– the control group (during the whole period)