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REGULATION OF HOMEOSTASIS WITH PRODUCTS ENRICHED BY ANTIOXIDANTS IN ATHLETES FROM LOW-INTENSITY SPORTS

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Aim. The article deals with establishing the effect of food, enriched with antioxidants, on people, practicing low-intensity sports, to forecast changes in homeostasis. **Materials and methods.** We used the data obtained from participants aged 25–35 (40 persons), practicing low intensity sports on a regular basis twice a week. As antioxidants, we used micronized taxifolin (0.58 % to product mass), chaga extract (5.76 % to product mass), and fucoidan (0.5 % to product mass). To assess the effect of enriched products on homeostasis, we performed the study of hematological and biochemical indicators with the help of non-contact blood analyzer. **Results.** We performed the analysis of metabolism after adding in a person's diet the products, enriched with biologically active substances. We also wanted to study the metabolic effect of changing a person's diet. We established that, in general, the inclusion into a person's diet of antioxidant enriched products do not result in a decrease of lipid and carbohydrate metabolism. However, antioxidant enriched products have a multidirectional influence on carbohydrate and lipid metabolism and enzymatic activity. From the prognostic point of view, there is a minimization of the risks of oxidative stress after the inclusion of food products, enriched with micronized taxifolin, into the diet of athletes from low-intensity sports. In comparison with other groups, there are no changes in the concentration of acetylcholinesterase (248.70 ± 2.4 umol/l; reference values 220–278 umol/l) after the decrease of amylase concentration. **Conclusion.** Homeostatic regulation is provided by the inclusion of specialized foods, which minimize the risks of oxidative stress, into a diet of athletes, involved in low-intensity sports.

Keywords: *homeostasis, specialized foods, sport loads, non-contact methods.*

Introduction. Homeostatic regulation is perfectly provided by the creation of an optimal diet for people, involved in sports of various intensity. There are different approaches to the regulation of metabolism, including individualization of a diet and changes in enzymatic activity that determine the speed of the entire polyenzymatic process. It was established that each person has his own metabolic characteristics, associated with the respective needs of energy food substrates, compensating muscle activity.

There is a disturbance of the balance between the supply of energy enriched substrates and their use at the adaptation stage during the training. This results in the disbalance between the production of active oxygen forms (AOF) and adequate antioxidant protection [10]. The formation of high AOF concentrations leads to the exhaustion of the system of antioxidant protection and intensifies destructive processes. It was proved that the inclusion of biologically active substances (BAS) of antioxidant activity into a diet decreases destructive processes, inhibits arrhythmia development, and stabilizes heart rhythm [2–4, 6, 9].

There are various methods of studying metabolism in the body and certain organs. For example, there are the method of balance experiments, method of isolated organs, method of marked atoms, and angiostomy. The method of balance experiments consists in determining the amount of the organic substances received and finished products obtained. Some works describe the application of non-contact methods for studying stress-induced changes in hormonal and immune homeostasis [5]. Other works are dedicated to assessing functional status in pediatrics using saliva indicators [1] and detecting biochemical and hematological indicators in racing skiers during adaptation [7].

The application of non-contact methods for controlling metabolic changes can be of prognostic value after the inclusion of innovative enriched products into a diet of people, involved in sports.

Materials and methods. We used the data obtained from volunteers aged 25–35 (40 persons), practicing low intensity sports on a regular basis twice a week. The program (fig. 1) was focused on apparently healthy volunteers, exposed to various physical loads. We performed a randomized double-blind placebo control studies during March – April 2017 and May – June 2018. We registered the data received from participants during the entire period of the experiment (1 month from the inclusion of the participant into the program). All participants received bread every day for 24 days (except for holidays and weekends).

There are different approaches to minimizing the risks of oxidative stress. The most interesting, in our opinion, is the study of the participation of soluble BAS in neutralizing oxidative stress. In this case, BAS play a role of the low molecular weight interceptors of oxygen active forms [12, 13]. Therefore, as adaptogens of antioxidant, immunotropic, antidiabetic, antibacterial, and antiviral efficacy we used the following ingredients:

– sulfated heteropolysaccharide of brown algae and some echinoderms – fucoidan extracted from *Kjellmaniella crassifolia* brown algae in the laboratory of Dalian University of Technology (PRC) [11];

– taxifolin powder extracted from the Dahurian larch (*Larixgmelinii*) with a taxifolin mass fraction of no less than 97.0 % (State Registration Certificate № RU 77.99.11.003.E.018404.05.11 dd. 06.05.2011). Taxifolin was micronized by ultrasound [17];

– dry water-soluble extract of *Chaga mushroom extract powder* (produced by Ametis company, Technical Specification 10.89.19-035-70692152-2016, State Registration Certificate № RU.77.99.11.009.E.006382.12.16 dd. 19.12.2016).

The assessment of antioxidant activity of the BAS used revealed that the total concentration of antioxidants varies in a significant range from 4.90 ± 0.3 to 114.30 ± 0.3 mg of ascorbic acid.

To perform studies in laboratory conditions, we baked 4 samples of tin bread using the recipes developed: wheat-rye bread without BAS (placebo); wheat-rye bread enriched with fucoidan (0.1% to flour weight); wheat-rye bread enriched with chaga extract (0.576% to flour weight);

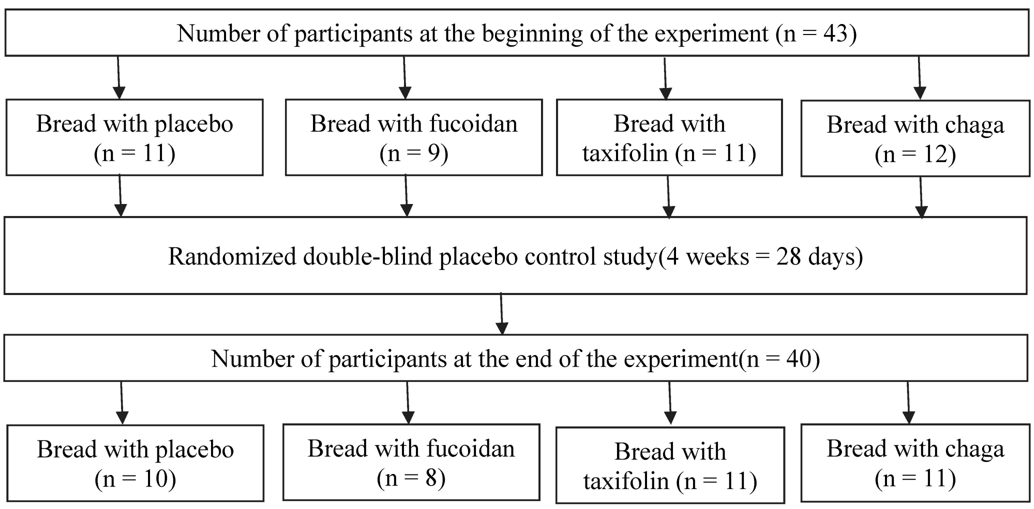

Fig. 1. Scheme of the study about the effect of BAS enriched products on homeostasis*

*The study was approved by the ethical committee of South Ural State University. Participant inclusion criteria: age of 18–50 years; informed consent provided in compliance with the Law; participants should be apparently healthy (absence of chronic diseases and medical contraindications to participation). Participant exclusion criteria: age of less than 18 years; participation in other clinical studies; chronic diseases; failed medical examination and laboratory tests.

wheat-rye bread enriched with micronized taxifolin (0.058% to flour weight).

To assess the effect of enriched products on homeostasis, we performed a hematological and biochemical study of blood indicators in volunteers before and after consuming enriched products. We conducted the study at the premises of Scientific and Research Center for Sports Science (Institute of Sports, Tourism and Service). We used a non-contact blood analyzer (AMP, Ukraine, registration certificate No. ФСЗ 2008/02305).

Results and discussion. Having studied blood indicators, which characterize carbohydrate metabolism, we obtained the following data: in volunteers from the control group at the end of the experiment we registered decreased values of lactic acid (0.99 ± 0.20 mmol/l) and glucose concentration (4.02 ± 0.15 mmol/l) in comparison with the data obtained at the beginning of the experiment. We obtained the same results in terms of lactic acid and glucose concentration in the first and in the third groups. The first group received bread with fucoidan, the third group consumed bread with chaga extract. In the second group, which received bread enriched with micronized taxifolin, the indicators of lactic acid (0.99 ± 0.14 mmol/l) and glucose (4.55 ± 0.36 mmol/l) at the beginning and at the end of the study remained almost the same.

Glycogen concentration (14.90 ± 0.25 mg %) in the control group also remained unchanged. In the first and in the third groups, we did not reveal any statistically significant changes in glycogen concentration in comparison with the second group, which consumed bread enriched with micronized taxifolin. This group demonstrated increased values of glycogen from 13.16 ± 0.40 mg % to 14.29 ± 0.21 mg % both within the group and comparing with the control group. At the same time, all indicators remained within reference values for this age group before and after the experiment.

During the analysis of lipid metabolism, we revealed that at the end of the experiment total cholesterol concentration and low-density lipoproteins in the control group demonstrated an upward trend. At the same time, high-density lipoproteins and triglycerides had a downward trend.

The first group, which consumed bread enriched with fucoidan, demonstrated a downward trend for all indicators of lipid metabolism. In the second group, we registered multidirectional changes in the indicators of lipid metabolism. In particular, by the end of the experiment, there was an upward trend for total cholesterol concentration, low-density lipoproteins, and triglycerides, under the decrease of high-density lipoproteins. In the third group, which consumed bread with chaga extract, there was an increase of total cholesterol (up to 5.07 ± 0.12 mmol/l) and low-density lipoproteins (2.31 ± 0.02 mmol/l) under the decrease of high-density lipoproteins and triglycerides (1.07 ± 0.10 mmol/l).

The indicators of lipid metabolism were within reference values for this very age group. The only exception is low-density lipoproteins, which were below the reference values in all groups at the beginning and at the end of the experiment.

Having studied blood indicators, which characterize enzymatic activity, we received the following data: in the control group, we registered an upward trend for acetylcholinesterase (256.15 ± ± 2.5 umol/l) and amylase concentration (17.30 ± ± 0.75) in comparison with the beginning of the experiment.

In the first group, which consumed bread with fucoidan, we registered the same tendency but less pronounced than in the control group.

In the second group, which consumed bread enriched with micronized taxifolin, we registered that acetylcholinesterase concentration remained almost unchanged, amylase concentration increased insignificantly, but this was less pronounced than in the control group. However, in the third group, the indicators studied were different as there were no changes in acetylcholinesterase concentration under the decrease of amylase concentration by the end of the study.

The study of lipid and carbohydrate metabolism and enzymatic activity in four groups (Table 1) revealed that consuming bread enriched with various BAS of antioxidant activity demonstrated differences in homeostasis in comparison with the control group (placebo controlled).

Therefore, in the control group, we revealed tendencies to a decrease of lactic acid and glucose concentration under the absence of changes in glycogen, increased values of total cholesterol, low-density lipoproteins, cholinesterase, and amylase, and decreased values of triglycerides and high-density lipoproteins.

In the first group, which consumed bread with fucoidan, there was a downward trend in the indicators of carbohydrate metabolism. In particular, there was a decrease of lactic acid and

Table 1

Dynamics of blood indicators for groups, which consumed various enriched products (direction of changes in concentration)

Indicators, cu. Reference values	Control group	Group 1	Group 2	Group 3
Carbohydrate metabolism				
Lactic acid concentration	↓	↓	—	↓
Glucose concentration	↓	↓	—	↓
Glycogen (mg %)	—	—	↑	—
Lipid metabolism				
Total cholesterol	↑	↓	↑	↑
Low-density lipoproteins	↑	↓	↑	↑
Very low-density lipoproteins	—	↓	↑	—
High-density lipoproteins	↓	↓	↓	↓
Triglycerides	↓	↓	↑	↓
Enzymatic activity				
Acetylcholinesterase	↑	↑	—	—
Amylase	↑	↑	↑	↓

*— – no changes in concentration by the end of the experiment in comparison with initial values; ↓ – downward trend at the end of the experiment in comparison with initial values; ↑ – upward trend at the end of the experiment in comparison with initial values.

glucose under the absence of changes in glycogen. There was also a downward trend in the indicators of lipid metabolism under a relative activation of enzymatic activity and cholinesterase, but this was less pronounced than in the control group.

The study of lipid and carbohydrate metabolism and enzymatic activity in the second group, consuming bread enriched with micronized taxifolin, revealed that there is an upward trend in glycogen concentration under the absence of changes in glucose and lactic acid concentration. This occurred under multidirectional changes in lipid metabolism in comparison with the control group. In particular, there was an increase in total cholesterol concentration, low-density lipoproteins, and triglycerides under the decrease of high-density lipoproteins and amylase.

The study of lipid and carbohydrate metabolism in the third group, which consumed bread with chaga extract, revealed an upward trend in lactic acid and glucose concentration under the absence of changes in glycogen and acetylcholinesterase concentration, the increase of cholesterol and low-density lipoproteins, and the decrease of high-density lipoproteins, triglycerides, and amylase.

Conclusion. The data obtained allow us to conclude the following:

Food products enriched with antioxidants do not worsen the indicators of lipid and carbohydrate metabolism. At the same time, food products enriched with BAS influence multidirectionally carbohydrate and lipid metabolism and enzymatic activity. In all participants the indicators studied remained within the reference values for a corresponding age group, except for low-density lipoproteins. Low-density lipoproteins were below the reference values in all participants during the entire experiment.

Food products enriched with BAS minimize the risks of oxidative stress in athletes, receiving moderate loads.

The application of non-contact methods remains relevant for controlling metabolism of BAS enriched products of antioxidant activity in athletes.

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ВОЗМОЖНОСТИ РЕГУЛИРОВАНИЯ ПРОЦЕССОВ ГОМЕОСТАЗА ПРИ ВКЛЮЧЕНИИ В РАЦИОНЫ ПИТАНИЯ ЛЮДЕЙ, ЗАНИМАЮЩИХСЯ СПОРТОМ МАЛОЙ ИНТЕНСИВНОСТИ, ПРОДУКТОВ, ОБОГАЩЕННЫХ АНТИОКСИДАНТАМИ

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Цель. Анализ воздействия на организм людей, занимающихся спортом малой интенсивности, продуктов питания, обогащенных антиоксидантами, для прогнозирования изменений процессов гомеостаза. **Материал и методы.** Представлены данные исследований испытуемых в возрасте 25–35 лет (всего 40 человек), занимающихся спортом стабильно (тренировки малой интенсивности 2 раза в неделю). В качестве антиоксидантов применяли: микронизированный дигидрокверцетин (0,58 % к массе продукта), экстракт чаги (5,76 % к массе) и фукоидан (0,5 % к массе). Для оценки влияния включения обогащенных продуктов на процессы гомеостаза было проведено исследование гематологических и биохимических показателей с помощью неинвазивного анализатора крови. **Результаты.** Проведен анализ характера метаболизма при включении в рационы питания продуктов, обогащённых разными биологически активными веществами (БАВ), особенностей влияния измененных рационов на энергетический обмен. Установлено, что применение в рационе питания продуктов, обогащенных антиоксидантами, в целом не приводит к ухудшению показателей липидного, углеводного обменов, но оказывает разнонаправленное влияние на углеводный и липидный обмен, а также на ферментативную активность. С прогностической точки зрения имеет место минимизация рисков оксидативного стресса при применении продуктов питания, обогащенных микронизированным дигидрокверцетином (МДГК), в рационе у спортсменов, получающих умеренные физические нагрузки. Установлено отличие от показателей в других группах отсутствием изменения концентрации ацетилхолинэстеразы (248,70 ± 2,4 мкмоль/л при норме 220–278 мкмоль/л) при снижении концентрации амилазы. **Заключение.** Включение в рационы питания людей, занимающихся спортом малой интенсивности, специализированных продуктов питания для минимизации рисков оксидативного стресса, обеспечивает регуляцию процессов гомеостаза.

Ключевые слова: *гомеостаз, специализированные продукты, спортивные нагрузки, неинвазивные методы.*

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