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Original Article

Endurance of athletes after consuming foods of high nutritional value in daily nutrition

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Abstract:
The training process of athletes is accompanied by a high level of metabolism and significant biochemical and morpho-functional changes in the body. To effectively increase physical fitness and restore the body of people involved in sports, it is necessary to provide them with adequate nutrition, especially during periods of intense training. This can be realized through the inclusion of foods with increased nutritional value in diets. ***Research objective***: To test the developed recipe for shortbread cookies with the addition of viburnum berry meal in sports nutrition for young athletes. ***Materials and methods***. Testing of the use of cookies with the addition of viburnum berry meal was carried out among student-athletes of the Siberian Olympic Reserve School. 30 first-year students (average age 16.5±1.2 years) took part in the project. All students were divided into 2 groups of 15 people: experimental (EG) and control (CG). Participants in the experimental group ate shortbread biscuits containing viburnum berry meal every day for breakfast and lunch for 6 months. All participants in the experiment were athletes who engaged in sports from 8 to 12 hours a week. At the beginning and at the end of the project, students EG and CG were tested for general and speed-strength endurance of the muscles of the lower extremities. ***Results***. The use of shortbread cookies with viburnum meal in the diet for 6 months made it possible to increase the overall endurance of boys and girl's athletes of the experimental group by 19.9 and 11.2%, which is significantly more than that of the athletes of the control group (2.6 and 1.1%). By the end of the experiment, the speed-strength endurance of the muscles of the lower extremities increased in boys and girls of the experimental group by 71.4 and 56.0%, respectively. In the control group of athletes, the increase in test values was 17.2 and 3.8%. ***Conclusions.*** The developed recipe for shortbread cookies with viburnum meal is an ergogenic product of increased nutritional value. It can be considered a promising source of dietary fiber, vitamins and proteins for the body and is recommended for use in the nutrition of athletes.
Key Words: **physical training, sports nutrition, natural food raw materials, strength, endurance.**

Introduction

An athlete's performance of an educational and training load greatly increases the activity of all morphofunctional systems of the body and its metabolism. A significant increase in metabolism in the body of athletes requires a higher consumption of ergogenic aids. It is known that a lack of proteins, carbohydrates, vitamins and minerals negatively affects a person's physical performance during sports activities (Bader et al., 2018; Zemtsova et al., 2020).

Intense physical activity is accompanied by an increase in oxygen consumption by working muscles. At rest, an athlete's muscles receive about 20% of the total blood flow. During physical work, oxygen consumption approaches 80% (D'Angelo & Rosa, 2020). This often causes oxidative stress and inflammation, which is caused by a decrease in the body's antioxidant defenses (Harun et al., 2017). Metabolic imbalances and increased superoxide production lead to damage to mitochondrial structure, which can inhibit the body's adaptive cells, especially during high-power exercise (Hostrup, & Bangsbo, 2017). Therefore, scientists and sports professionals are constantly searching for foods and supplements that can improve athletic performance, increase recovery, and reduce the effects of oxidative stress (D'Angelo & Rosa, 2020; Valentina, 2022). Amino acids play

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a particularly important role in sports nutrition. They are one of the important macronutrients for maintaining many body functions (Welis, 2017).

Currently, the use of non-traditional supplements and biological compounds has become popular among professional and amateur athletes (Zamri et al., 2022), which are represented in a wide variety.

Following running training in older adults, supplementation with Paulinia kupana (guarana) has been found to improve cardiovascular endurance, increase lower limb muscle strength, normalize heart rate, and reduce blood lactate levels (Wibowo et al., 2023). Other non-traditional products include the addition of nitrate-rich beet crystals (Saleh et al., 2023). The authors showed that beets may be a useful product for increasing exercise performance in poorly trained people and that they may have a health-improving effect on the cardiovascular system. The positive use of curbaril extract in sports activities (Cavalcante et al., 2022) is due to the content of flavonoids in it, which is why an antioxidant effect is observed. There are studies that show the positive effects of L-citrulline when combined with malate (Gonzalez & Trexler, 2020; Naimah et al., 2022). In the work of Mohamed Mirza Dawlath Mohamed et al. (2021) showed the beneficial effects of adding Malaysian Tualang honey to food. It improves muscle performance in young men with low physical activity. A number of authors (Kolman et al., 2018) presented studies of the properties of minced cod fish with the addition of juice from blueberries and cranberries. They were used as additives in curd and fat products in sports nutrition. There are interesting scientific studies on polyphenol supplementation that have been obtained from various fruits (Tosif et al., 2021; Zamri et al., 2022). The authors found that polyphenols contained in fruits and berries improve human physical performance, which allows them to be recommended in sports practice.

The use of food products and supplements allows you to normalize metabolism and recovery processes after competitions. Specialized food products and biological additives for athletes' food should not: have a harmful effect on human health; contain potent, psychotropic substances and doping. At the same time, numerous studies confirm the fact that some specialized products for nutrition of athletes may contain substances prohibited in sports without indicating information about their content in the products on the label. Therefore, research aimed at creating safe food products for athletes, balanced in essential nutrients based on the use of natural raw materials, seems relevant. As a promising source of nutrients, secondary raw materials are of practical interest, in particular, meal from Viburnum berries (Konarska & Domaciuk, 2018; Kajszczak et al., 2020).

Meal from Viburnum berries contains essential amino acids, flavonoids, vitamins, micro and macroelements, and dietary fiber (Akimov, 2020). The use of such natural raw materials in flour confectionery products will enrich them with vegetable protein, vitamins, dietary fiber and change the calorie content of the finished product. This, in our opinion, should have a positive effect on the physical fitness of athletes. There is no information in the scientific literature about the effectiveness of using confectionery products that contain viburnum berry meal in sports nutrition. Therefore, the development of a recipe and technology for preparing shortbread cookies with viburnum viburnum meal and testing its effectiveness in sports nutrition seems relevant and necessary in the practice of the training process.

Research objective: To test the developed recipe for shortbread cookies with the addition of viburnum berry meal in sports nutrition for young athletes.

Material & methods

The first stage of the research included the development of a recipe and technological requirements for the preparation of shortbread cookies with viburnum berry meal. The compliance of this product with the regulations of the state quality standard for organoleptic, physico-chemical and microbiological requirements was determined, and the shelf life of the product was studied (Kolman et al., 2019). The microbiological parameters of the powder obtained from defatted viburnum berry meal were determined. The microbiological indicators of the powder from viburnum meal did not exceed the permissible levels and complied with the requirements of the Technical Regulations of the Customs Union 021/2011 "On food safety".

Meal is a product obtained after extracting fat from oilseeds with organic solvents in distillers and evaporators. Meal is a low-fat powder. According to our data, it has been established that 100 g of viburnum berry meal (Viburnum opulus L.) contains: water – 4.95%, proteins – 33%, dietary fiber (DF) – 39%, glucose – 23%. The dry weight of viburnum berry meal in shortbread cookies was 38.75% of the total dry matter content. The yield of one serving of cookies was 192 g.

The second stage of the study included studying the effect of eating shortbread cookies with the addition of viburnum berry meal on the motor qualities of athletes. Testing was carried out among student-athletes at the Olympic Reserve School in the city of Krasnoyarsk (Russia). 30 first-year students (specialty 49.02.01 "Physical Education") aged 16 to 17 years (average age 16.5±1.2 years) took part in the experimental project.

All students were divided into 2 groups of 15 people (10 boys and 5 girls in each group): experimental group (EG) and control group (CG). Participants in the experimental group ate shortbread cookies with viburnum berry meal for breakfast and lunch every day for 6 months. All participants in the experiment were athletes who were involved in sports from 8 to 12 hours a week and had sports ranks. At the beginning and at the

end of the project, students EG and CG were tested for general endurance using the motor test "running 2000 m", m/s and speed-strength endurance of the muscles of the lower extremities using the test "squatting for 30 s", number of times All students were familiarized with the plans for monitoring them, they gave written consent to participate in the study, which did not contradict the requirements for biomedical examinations set out in the 2008 Declaration of Helsinki.

The resulting material was processed statistically using generally accepted parametric methods. The computer program "Microsoft Office Excel" was used, where statistical processing of the obtained digital data was automatically carried out.

Results

The results of a chemical study of shortbread cookies, which contain viburnum berry meal, indicate an increase in the content of vegetable proteins and dietary fiber in the finished product and a decrease in fat content compared to the traditional cookie recipe, Figure 1.

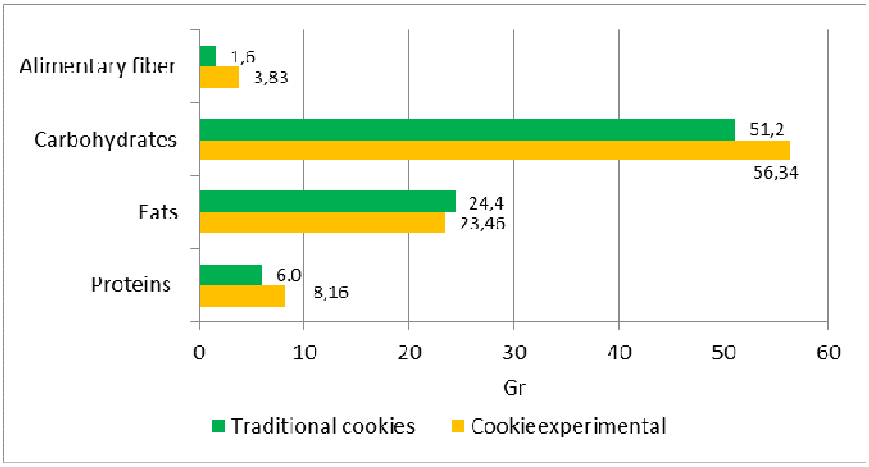

Fig. 1. Content of nutrients and dietary fiber in the experimental cookies and the control sample of the confectionery product (per 100 g)

Liver with viburnum berry meal contains 36.0 and 139.4% more proteins and dietary fiber, respectively, and 3.8% less fat compared to cookies prepared according to the traditional recipe, $p < 0.05$. The protein content in low-fat meal obtained from Viburnum berries is 34.12% of the absolute dry matter content. The calorie content of cookies with viburnum berry meal was 5.6% higher than traditional cookies, which is due to the higher content of protein, carbohydrates and dietary fiber compared to the control sample of cookies.

The use of cookies with viburnum berry meal in the diet of student-athletes affected the value of the overall endurance of the body. Figure 2 shows the results of milestone testing of general endurance in boys and girls EG and CG.

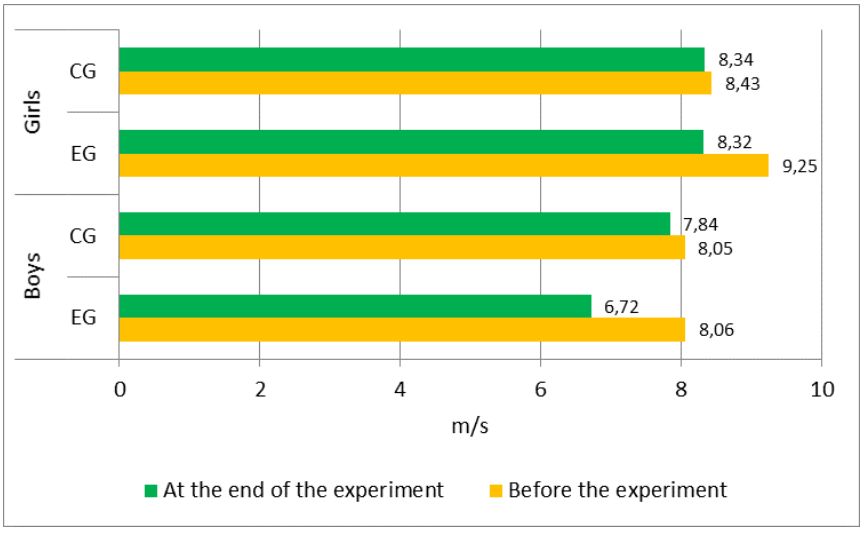

Fig. 2. Values of milestone indicators of general endurance in boys and girls EG and CG

As can be seen from Figure 2, after the experiment, the overall endurance of the boys and girls of the experimental group (whose diets included cookies with viburnum meal) increased by the end of the project, respectively, by 19.9 and 11.2% compared to the beginning of the study, $p < 0.05$. In boys and girls in the control group, overall endurance increased by 2.6 and 1.1%, respectively. During the experiment, an increase in speed-strength endurance indicators was found in students of both observation groups, Figure 3.

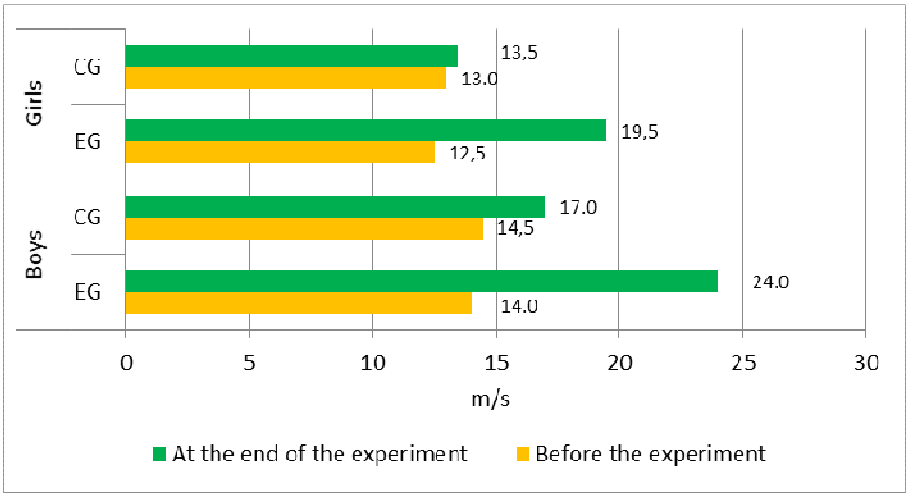

Fig. 3. Values of milestone indicators of speed-strength endurance boys and girls EG and CG

After the experiment, an increase in dynamic speed-strength endurance of the muscles of the lower extremities in boys and girls of the experimental group was found to increase by 71.4 and 56.0%, respectively, $p < 0.05$. In boys and girls in the control group, speed-strength endurance by the end of the study increased by an average of only 17.2 and 3.8%. As a result of the studies, it was established that when used in the diet of young men and women athletes for 6 months, cookies containing meal from Viburnum berries allowed a more significant increase in overall and speed-strength endurance compared to the control group, whose diet did not contain meal from viburnum.

Dicussion

Currently, there is an ongoing scientific discussion about food products that will maximize the performance of athletes in competitions, restore strength and increase the body's resistance to physical fatigue, the cause of which is exhaustion of the body as a result of long-term training (D'Angelo & Rosa, 2020; Valentina, 2022).

Based on the literature analysis, it was revealed that this problem can be solved by including food products balanced in terms of basic nutrients in the diets of athletes. In order to increase tolerance to physical and psycho-emotional fatigue of athletes, their diets include various specialized foods and dietary supplements (Kolman et al., 2018; Tosif et al., 2021; Zamri et al., 2022; Saleh et al.., 2023).

The inclusion in the list of substances prohibited in sports by a wide group of various chemical compounds that may be contained in medications, biological food additives, and recovery chemicals increases the attention of scientists to scientific research that is aimed at studying the issue of the use of nutrients based on natural raw materials by athletes. Such food compounds include viburnum berry meal (Konarska & Domaciuk, 2018; Kajszczak et al., 2020). To feed athletes, we have developed a recipe and technology for making shortbread cookies with viburnum meal (Kolman et al., 2018).

The physicochemical properties of viburnum berry meal have been studied quite well. It is known that viburnum berry meal is a source of essential amino acids, vitamins, minerals, dietary fiber and flavonoids, which are powerful food antioxidants and belong to the group of polyphenols (Akimov, 2020). They inhibit the formation of reactive oxygen species. It is known that intense physical activity causes a manifold increase in oxygen consumption in the human body, which leads to the appearance of reactive oxygen species, the occurrence of oxidative stress and the development of tissue inflammation (Harun et al., 2017).

In Fatin Nur Shahira Zamri et al. (2022) showed that the use of polyphenol supplements, which were obtained from fruits and berries, in the diet of athletes increases physical performance compared to athletes who received a placebo. According to the authors, this is due to the effect of polyphenols on stimulating nitric oxide (NO) production. It provides higher oxygen perfusion to muscle tissue during exercise (Linoby et al., 2020). It is also well known that NO is important in stimulating muscle glucose utilization and fat oxidation (Asraff et al.,

2022). The presence of flavonoids in various fruits and berries, in particular in viburnum berry meal, makes these products especially valuable in the diet of people who perform significant physical activity.

Our results of testing general and speed-strength endurance of young athletes who received viburnum berry meal with shortbread indicate higher values of these motor qualities compared to athletes who did not receive viburnum berry meal. We believe that this is due to the stimulating effect of polyphenols contained in viburnum berries on nitric oxide, which increased the physical performance of athletes in the experimental group. This is consistent with the opinion of other authors who found an increase in the physical performance of athletes after consuming cherries, berries and pomegranate fruits (Zamri et al., 2022). A positive role in increasing the general and speed-strength endurance of athletes in the experimental group can be exerted by an increase of 5.6% in calorie content and by 36.0% in protein content of cookies with viburnum berry meal. This provides advantages in the performance of motor tests by athletes in the experimental group compared to the control group and ensures hypertrophy of skeletal muscles. This is indicated by research by D.T. Mario et al. (2022), who obtained significant muscle gains when including increased amounts of protein in their diet.

We believe that future research should be aimed at assessing the effect of viburnum berry meal on the state and development of other motor qualities of athletes (strength, speed) and coordination abilities.

Conclusions

A recipe and technology for producing shortbread cookies with the addition of viburnum berry meal have been developed for sports nutrition for young athletes. Cookies with viburnum berry meal contain 36.0% more protein and more than 2 times more dietary fiber, 3.8% less fat compared to cookies prepared according to the traditional recipe. The content of plant amino acids in low-fat meal obtained from viburnum berries reaches 34.12% of the absolute dry matter content. The calorie content of cookies with viburnum berry meal was 5.6% higher than traditional cookies. The introduction of shortbread cookies with viburnum meal into the diet for 6 months made it possible to increase the overall endurance of boys and girl's athletes of the experimental group by 19.9 and 11.2%, which is significantly more than that of the athletes of the control group (2.6 and 1.1%). By the end of the experiment, the speed-strength endurance of the muscles of the lower extremities increased in boys and girls of the experimental group by 71.4 and 56.0%, respectively. In the control group of athletes, the increase in test values was 17.2 and 3.8%.

The developed shortbread with viburnum meal is a natural product of increased nutritional value. It can be considered a promising source of plant proteins and dietary fiber; it can be recommended for use in the nutrition of athletes.

Conflicts of interest. The authors declare no conflict of interest.

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