Original Article

Multiple action specialized product: Production and effectiveness

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ABSTRACT

The use of specialized products with specific functions iscrucial in professional sports, as high-performance athletics is characterized by significant emotional stress and a high level of physical activity. Clinical trials were conducted to evaluate the effectiveness of the developed specialized product, which was introduced into the diet of highly qualified athletes, including swimmers, road cyclists, and biathletes. The athletes of the main group included a biologically active supplement (BAS) in their diet for 20 days, taking one tablet during breakfast and lunch. The control group did not take any dietary supplement. All study participants had the same living conditions and standard eating plans. It was found that in the main group of swimmers after the diet therapy, the average cyclic power (T-1) increased to 139.5 ± 23.3 W ($P < 0.05$), while in the control group these indicators were 127.2 ± 17.3 W. In road cyclists, the power of physical activity increased by 8% (at the level of PAN-2) with a consistent increase in heart rate to 170, 180, and 185 beats/min., which guarantees energy supply to muscles with an economic and increasing effect of 810% (in the control group, such changes were not found). Biathletes showed increased oxygen consumption and exercise power at a constant heart rate ($P < 0.05$). The obtained materials can serve as evidence of the functional effectiveness of the combined use of the food supplement to increase the functional capabilities of athletes in the pre-competition period.

Keywords: Specialized products, Food supplements, Production, Quality, Effectiveness, Functional properties

Introduction

New-generation sports nutrition products result from the use of highly intelligent, science-intensive food technologies that incorporate applied and fundamental sciences such as medicine, the science of nutrition, biochemistry, and physiology. Nutrition plays a key role in ensuring sporting results, and it can specifically influence metabolic processes in certain phases of sport training, with consideration to the individual characteristics of the athlete's body, their performance level, gender, and age [1-12].

The use of specialized products with specific functions, including biologically active supplements (BAS), is of particular importance in professional sport, as high-performance sport is characterized by significant emotional stress and a high level of physical activity [13-22].

Other points that seem to be important include tailoring a sports diet under high levels of physical and neuro-emotional stress; nutrition during the competition and in between training sessions; making sure that water-salt metabolism and thermoregulation are regulated; encouraging the development of

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muscle mass and correcting it; justifying the frequency of nutrition during training and reducing the volume of nutrition during competition; and the potential for both quantitative and qualitative changes in nutrition based on the training process methodology to achieve results [23-33].

The above-mentioned ways of addressing the issues of sports nutrition apply equally to biathletes, cyclists, and swimmers.

Materials and Methods

The objects of research are raw materials, finished products, and industrial samples of the newly developed form of food supplements. Raw materials whose quality and safety meet the requirements of applicable regulations were used for the production of food supplements.

When developing the formulas and technologies of the specialized product, modern, well-known instrumental methods were used to test quality, safety, and functions, with account to the established legal requirements. The reliability of the results obtained was confirmed by repeating the tests 6-10 times using mathematical statistics and computer programs.

A scientifically based composition of a specialized product in the form of a food supplement has been developed, containing in mg/1 capsule: Yohimbe (bark extract) - 5; ginger (root) - 25; ginseng (root) - 18; calamus (root) - 18; ginkgo biloba extract - 15; starch - 15; maral root (leuzea) - 18; zinc oxide - 2.5; tocopherol acetate 50% (vitamin E) - 10; pantohaemogen preparation - 0.02.

The manufacturing process for the food supplement is shown in **Figure 1** and includes the following main production steps.

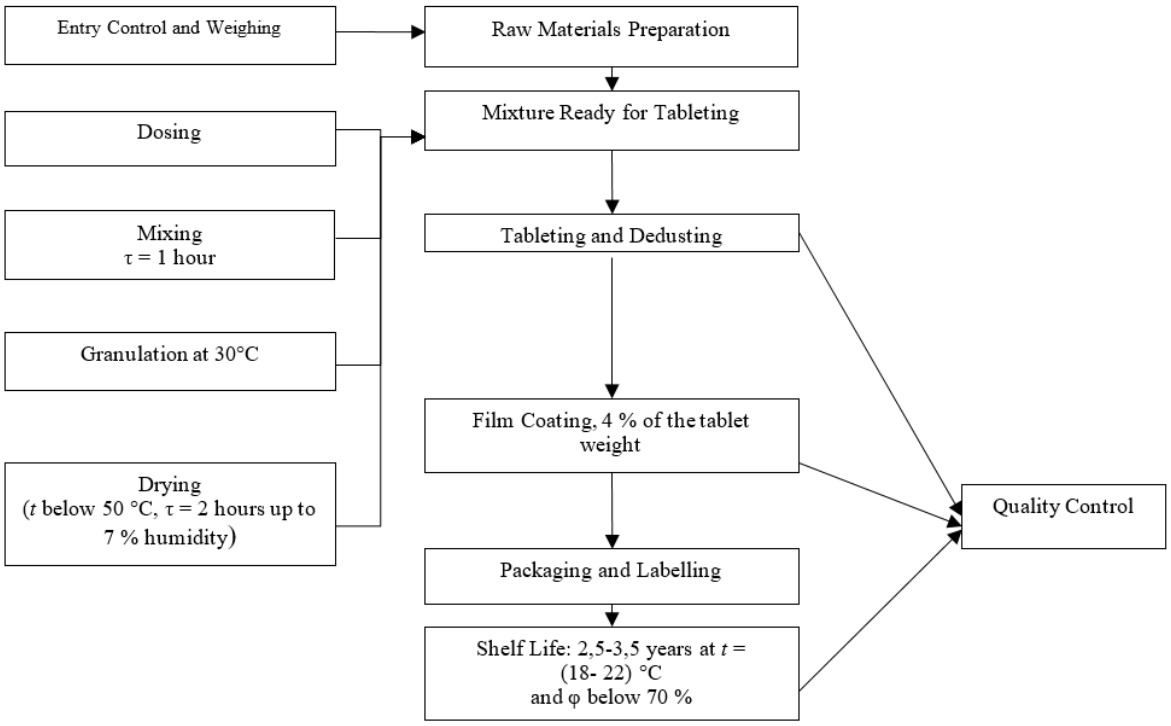

Figure 1. The manufacturing process

- Entry Control and Weighing. The control of incoming raw materials is based on the adopted working method.
- The raw materials are transported from the warehouses in labelled, sealed containers, and the quantity is recorded in the process sheet.
- Dosing. Raw materials are placed in containers labelled with the expiry date, quantity, and batch number.
- Sieving. The components are sieved through a vibrating sieve no. 4, SGS-30, after which they are placed in the mixer.
- Mixing is carried out in a V-shaped mixer, C-50 or C-300, for 1 hour until a homogeneous mass is obtained. The finished mixture is poured into a container, labelled and weighed, and a record is made in the enclosed process sheet.
- Granulation. Wet granulation was performed with the MAKIZ 013-01 extruder press machine with a die hole diameter of 1 mm. To form granules, distilled water was added as the granulation fluid (25% of the weight of the dry mixture). The wet granules had to be uniform, of the same color, and the temperature of the granules did not exceed 30°C.
- Drying was carried out at a temperature of 50°C in S-105 drying cabinets for 2 hours. The expected residual moisture content of the granules was 7%.
- Tableting and Dedusting. The resulting tablet mass is sent for pressing on a Killian RTM-E150 rotary machine with the maximum compression force of 50 N.
- Film Coating. Enteric film was applied by Accelocota-350 or Accelocota-150 coating systems. Enteric coating accounted for 4% of the total tablet weight.

- Packaging and Labelling. An automatic counting and packaging line is used. The products are packed into plastic jars, which are labelled in accordance with the requirements of the technical documentation. The produced food supplements are checked in an accredited production laboratory for quality and safety indicators for compliance with the specified requirements.

Tests were carried out on safety indicators (sanitary-hygienic and sanitary-toxicological studies), organoleptic and physicochemical indicators over 3.5 years of storage at a relative humidity of not more than 70% and a temperature of 18-22° C **(Tables 1-3)**. It was found that the indicators of abrasion resistance and breaking strength of the tablet form of the food supplement increase after 2.5 years of storage, which reduces disintegration, although this indicator is within the normal range.

Results and Discussion

Table 1. Effect of storage on organoleptic characteristics of the food supplement

Indicator	Shelf life, months							
	0	6	12	18	24	30	36	42
Appearance	The tablet shape is correct, oval, the surface is uniform and smooth, there are no damages, chips or sticking							
Color	Brownish red, uneven							
Taste and smell	The taste is neutral, the smell is specific							

The colour and smell are due to the special formulation of the specialized product that contains tocopherol, royal jelly and pantohaemogen in addition to herbal ingredients - ginger, yohimbe, ginseng, ginkgo biloba, calamus and leuzea.

Table 2. Effect of storage on physicochemical characteristics of the food supplement

Parameter	Storage, months							
	0	6	12	18	24	30	36	42
Weight of tablets, average, g	0.51 ± 0.9	0.51 ± 0.11	0.52 ± 0.12	0.51 ± 0.13	0.51 ± 0.10	0.51 ± 0.17	0.52 ± 0.10	0.51 ± 0.16
Disintegration, min	21.4 ± 0.8	21.5 ± 1.2	21.8 ± 1.5	22.5 ± 1.4	22.7 ± 1.3	23.0 ± 1.1	24.3 ± 2.2	27.4 ± 2.1
Breaking strength, N	94.2 ± 1.0	94.3 ± 1.4	94.5 ± 0.9	94.8 ± 1.3	94.9 ± 1.1	95.4 ± 1.5	97.0 ± 1.6	97.3 ± 1.4
Abrasion resistance, %	98.6 ± 0.05	98.7 ± 0.06	98.8 ± 0.05	98.8 ± 0.05	99.0 ± 0.06	99.2 ± 0.08	99.5 ± 0.08	99.8 ± 0.08

Table 3. Effect of storage on microbiological properties of the food supplement

Indicator		Acceptable level	Shelf life, months						
			0	6	12	24	30	36	42
Product weight, g, in which not allowed	E. coli	1 ,0	Not detected						
	S. aureus	1.0	Not detected						
	Pathogenic, including salmonella	10	Not detected						
	Coliforms (coliforms)	0,1	Not detected						
	QMAFAnM, CFU/g	Not more than $1 \cdot 10^4$	$1.4 \cdot 10^2$	$2.9 \cdot 10^2$	$5.3 \cdot 10^2$	$6.4 \cdot 10^2$	$1.4 \cdot 10^3$	$2.7 \cdot 10^3$	$4.4 \cdot 10^3$
	B. cereus, CFU/g	Not more than $2 \cdot 10^2$	Not detected						
	Molds, CFU/g	Not more than 100	-	-	-	2	6	8	12
	Yeast, CFU/g	Not more than 100	-	-	1	2	6	9	14

The preservation of vitamin E was studied; the results are presented in **Figure 2**. A decrease in tocopherol content by 4.4% was revealed after 42 months of storage.

$$y = -0.0643 x + 10.7999 \quad R^2 = 0.9729 \qquad (1)$$

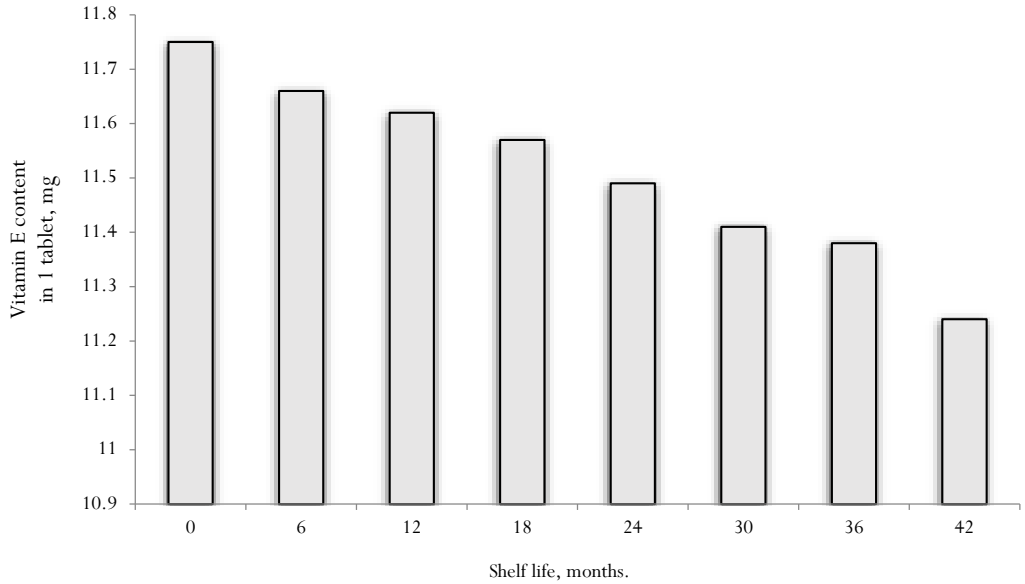

Figure 2. Effect of storage on the food supplement tocopherol content.

In general, it should be noted that the developed product meets all safety criteria. The specified characteristics of the food supplement have been determined **(Table 4)**.

Table 4. The specified organoleptic and physicochemical characteristics of the food supplement

Parameter	Value
Appearance	The tablet shape is oval
Weight of tablets, average, g	0.46–0.54
Color	Brown-red of different shades
Smell and taste	The taste corresponds to the composition, the smell is specific
Disintegration, min, no more than	31
Fracture strength, N, not less than	89
Abrasion resistance, %, not less than	98
Zinc content in 1 tablet, mg, not less than	2.1
Vitamin E content in 1 tablet, mg, not less than	11.2

The expiration period has been determined: 2 years at a temperature of (18-22) °C and relative air humidity of no more than 70%.

Obviously, the effectiveness of the food supplement may be analyzed by conducting clinical studies in appropriate groups of athletes.

The parameters characterizing the functional properties and effectiveness of the food supplement were studied in a group of 18 highly qualified swimmers. The age range was (18.8 ± 1.6) years old, their total sports experience (10.8 ± 1.7) years; their weight range was (74.6 ± 5.7) kg; their height range was (1.86 ± 0.08) m. The experimental group included 10 athletes, and the control group consisted of 8 people. Physical performance was assessed with the "ART-2" diagnostic computer complex. External respiration and the assessment system were studied using cardiac monitors (Polar Electro Acckurex Plus, Beckmen, and Cortex).

The athletes performed a specified stroke in the recorded tests: with increasing power (step test for 1 minute 10 times); with competitive activity (for 1 minute, T-1); with maximum activity (10 strokes, T-10). Pulmonary ventilation, oxygen consumption, and heart rate were recorded.

The athletes of the main group were prescribed, in addition to the diet, 1 tablet of the food supplement for 20 days during breakfast and lunch. The control group received no food supplement. All athletes had the same living conditions and similar eating plans.

Differences in loads in tests with competitive (T-1) and maximum activity (T-10) were determined between the groups of swimmers. In the main group of athletes, a change in average cycle power was established upon termination of the prescription period (171 ± 26.8) to (180.0 ± 31.9) W ($P < 0.05$). In the control group, this indicator was at the level of (148.3 ± 40.6) W before diet therapy and at its completion—(146.2 ± 28.1) W ($P > 0.05$).

The average cycle power (T-1) was (134.8 ± 20.2) W, after which an increase to the level of (139.5 ± 23.3) W was established ($P < 0.05$). In the control group, these indicators were (125.9 ± 17.7) and (127.2 ± 17.3) W, respectively ($P > 0.05$).

The results of the study are evidence of the importance of diet optimization in increasing performance (stroke power). The biochemical mechanism of the process under consideration is associated with the participation of methionine in the biosynthesis of creatine and protein in muscle tissue. The methionine substrate is included as a structural component of the food supplement. It should be noted that ATP resynthesis by the creatine phosphokinase pathway plays a key role in the processes of energy supply for short-term muscle work during its maximum intensity.

The obtained data demonstrate the feasibility of the comprehensive use of the tested products in training swimmers during the basic training period.

The composition of the food supplement makes it possible not to prescribe other biologically active complexes, including vitamin and mineral preparations, in addition to the athletes' diet.

The functional properties of the food supplement have also been clinically confirmed by including it in the diet of road cyclists and biathletes.

The tests were carried out in three stages:

- study of the existing eating plan;
- conducting baseline tests;
- retesting after intake of the specialized product.

The results of the study of the existing eating plan and analysis of the tests served as the basis for correcting the athletes' vitamin supply in accordance with physiological norms.

The athletes were tested by a physically specific load on ergometers, which, based on the characteristics of the exercises performed, provided real competition conditions. Along with the ergometers, a telemetric pulse meter was used (Polar Electro Acckurex Plus) in order to establish energy supply during the testing load. Beckmen instruments were used to study external respiration. Aerobic (PANO-1) and anaerobic (PANO-2) metabolic thresholds, critical power, and maximum oxygen consumption (MOC) were determined. To calculate the obtained data, the standard powers and pulse zones were adjusted. Dynamic changes in data were recorded and presented in a graphical digital form using computer programs.

The effectiveness of adaptation processes in biathletes during physical exertion was studied with the "Effex-2" computer-modified method. Psychomotor status was studied using tests that provide information on the stability and accuracy of movements, considering the factors of space-time parameters and physical efforts.

Individual characteristics of the athletes' personalities were determined with "Gradusnik" anxiety scales, SAN, Spielberger-Khanin, as well as Sopov sport motivation scales. In addition, the Luscher color projective method was used. The obtained data indicate the same volume of training loads and their intensity in the control and main groups.

The results of the study of existing eating plans showed an imbalance in the diet in terms of basic nutrients: an increase in the quota of animal proteins, simple, easily digestible carbohydrates with a lack of starch (polysaccharide), animal lipids, and a deficiency of vegetable fats. An insufficient content of essential micronutrients was noted.

The athletes' vitamin C status was 55% in winter and 69% in spring. It was shown that during the same period the number of athletes with polyvitamin deficiency (B1, B2, B6, B12, PP, A, E, D, and folic acid) increased. Insufficient vitamin A and D status was established. All this can have a negative impact on health and athletic performance under conditions of constant critical loads.

The functional properties of the food supplement were also assessed for a group of road cyclists. The group of road cyclists consisted of 8 athletes with (4.6 ± 0.3) years of experience in sports, an age range of (16.4 ± 0.4) years, a weight range of (66.3 ± 5.1) kg, and a height range of (1.78 ± 0.63) m. The control group also consisted of 8 road cyclists with (3.8 ± 1.1) years of experience, an age range of (15.5 ± 0.7) years, a weight range of (55.7 ± 9.5) kg, and a height range of (1.67 ± 0.11) m. The diet of the athletes in the main group additionally included 1 capsule of the food supplement for 20 days during breakfast and lunch. The control group received no food supplements. The athletes in both groups were in the same training conditions, had similar nutrition, and were characterized as basically healthy. The studies were carried out in spring and summer with a significant amount of specific physical exercise. A rising step load was used using a Monark bicycle ergometer for testing. The rotational resistance was increased in increments of 37.5 W in 6 steps for 3 minutes with an initial load of 75 W and subsequently with a maximum pedaling frequency-resistance in 6 steps for 1 minute.

It has been shown that after intake of the food supplement, the power of physical activity at the level of PAN-2 increases (by 8%), $P < 0.05$, with a consistent increase in heart rate—170, 180, 185 beats/min. The established result guarantees energy supply to muscles with an economic and increasing effect of 8-10%. In the control group of athletes, such changes were not detected.

Research data indicate a positive effect of the food supplement on performance in anaerobic and mixed zones.

In addition, tests of the specialized product in the diet of highly qualified biathletes were conducted. The group consisted of 10 biathletes with (10.2 ± 1.3) years of experience in sports, aged (22.4 ± 3.1) years, with the weight range of (69.3 ± 5.4) kg and the height range of (1.78 ± 0.03) m. The control group included 8 athletes with (9.4 ± 1.7) years of experience, aged (21.8 ± 3.2) years, with the height range of (1.78 ± 0.05) m and the weight range of (69.8 ± 7.1) kg.

To simulate a rising step load, a treadmill with an increasing incline angle was used. The load consisted of 7 steps of 3 minutes (from (72 ± 9) to (402 ± 5.6) W). The main group of biathletes was prescribed 1 capsule of the food supplement during breakfast and lunch for 20 days. No food supplement was prescribed for the control group. All athletes were in the same pre-competition

training conditions, were basically healthy, and had the same amount of exercise.

As a result of testing the level of performance, it was established that the course intake of biocomplexes increases oxygen consumption ($P < 0.05$). The power of the exercises performed increases under conditions of heart rate values of 120, 170, 180, and 185 beats per minute. The research materials indicate the formation of new functional capabilities in the athletes' bodies aimed at improving the oxygen supply to cells during intense physical activity. The data from psychomotor potential tests indicate the possibility of a potential increase in strength parameters and the accuracy of spatial movement regulation by 3% and 9%, respectively. Visual-motor coordination of movements increases by 8%.

The dynamics of the studied parameters in the control group showed a decrease in the accuracy of regulation of power parameters by 2% and by 3.5% in visual-motor coordination. At the same time, spatial parameters of movement increased by 4%. The obtained materials can serve as evidence of the functional effectiveness of the combined use of targeted food supplements to increase the functional capabilities of athletes in the pre-competition period. The food supplement also performs an individual antioxidant function, ensuring the functioning of the nervous system.

Conclusion

Based on the research conducted, the following conclusions can be made:

- it is advisable to improve the athletes' vitamin status considering the intensity of physical activity, the characteristics of the training process, and the season of the year.
- the possibility to implement the synergistic activity of multi-action food supplements in the training process of biathletes.

Diet therapy in the form of food supplements is necessary to ensure conditions for optimizing metabolic and energy resources during the competitive period and replenishing the loss of essential nutrients under stress conditions that exceed the body's adaptive reserves. Antioxidant functions of vitamins C, E, and selenium are of great importance for correcting metabolic disorders. At the same time, the developed product performs not only an antioxidant function but also enhances the efficiency of the nervous system under conditions of neuro-emotional stress.

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Ethics statement: The study was conducted according to the guidelines of the Declaration of Helsinki.

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