

MODULES BASED ON NUTRITIONAL ADAPTOGENES FOR ASTRONAUTS AND GROUND CONTROL

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Abstract

The established reasonable causality and close relation between physical activities of astronauts and their nutritional regime provoke the necessity of creating appropriate biostimulating foods in the form of food additives complex.

On the basis of highly developed methods 2 specified modules are created, including 6 new types of lyophilized biostimulants, rich in nourishing proteins, essence aminoacids, poly unsaturated fatty acids, plant fibres, probiotic complexes of antioxidants, vitamins, micro and macroelements, lipotropic and other bioactive substances. Combined with suitable Bulgarian space foods, developed as the First Space Menu by the Institute of Cryobiology and Food Technology, the new type of biostimulating foods provide through alimentary way effective bioprotection of the body under extreme labour conditions and help to maintain high level of vitality, activity of the astronauts and the ground control during the preparation-training period as well.

Keywords: *lyophilized biostimulants, adaptogenes, space foods*

During the last years the multi-aspect investigations into space medicine and biology offer precious data revealing the influence of some factors over the human organism in space conditions. The most characteristic syndrome – “motion sickness”, typical for humans during space flight, is due to increased acceleration. In response to the stress factors occurring during space flight, the main protective reaction of the organism is to mobilize the regulatory mechanisms of homeostasis and adaptive reorganization of metabolism. At the same time, such durable action of this complicated complex of factors over the human body leads to reduction of the adaptive abilities, working capacity, immune resistance and a series of

pathological metabolism disorders and the whole body as well. The total dynamic balance, physical and mental activity of humans, also in space condition, depends on three main groups of factors:

- 1) factors due to flight dynamics;
- 2) physico-hygienic factors;
- 3) psychological factors.

Nutrition is one of the main physico-hygienic factors of the working capacity. As an outer synchronizer, the alimentary factor has a determinative role for maintaining high level of the astronaut's working capacity, adaptation and healthy status. Its role is to provide protection of the human organs and systems under extreme conditions of life during space flight and it helps to improve the adaptive ability of the organism and the overall working capacity. That is why, the organism under extreme conditions has to be provided with adequate quantitative and qualitative source of nutrition substances equivalent to the intensity of adaptive processes.

Main objective: "Creation of multi-aspect nutrition biostimulant modules for improving the working capacity, activity and adaptation of the organism under extreme conditions during space flight and training".

For the implementation of the main objective we apply the following approaches:

Scientific approach:

I. Formulating the composition of the new biostimulants:

• **Based on the pathogenic principle** - in order to obtain the necessary effect on the human organism under extreme conditions, the composition of each functional food is in accordance with the specifics of the metabolic processes, energy consumption, substrate utilization and character of the adaptive changes depending on the duration and type of the physical exercises, nervous and physical exhaustion, training programme (by the ground control) etc. In order to achieve better efficiency and wide-spectrum influence on the above-mentioned pathological processes during the space flight and training exercises by the ground control, we have developed multicomponent biostimulating functional foods. Furthermore, the so-called "oxidative stress" of the organism and the professional disbiosis, occurring under extreme conditions, can be overcome due to the composition of the new food adaptogens with biologically active substances with high antioxidant index in combination with probiotic, prebiotic and enzyme complexes.

• **Based on the preliminary dosed qualitative and quantitative composition** in respect to the characteristics of the final product, its organoleptic

properties, stable consistency and high utility, and microbial purity.

• **Based on the national and European health regulations for food safety and quality**

Developed in compliance with the above regulations, the new food adaptogens can be classified as follows:

- 1) **Food adaptogens with stimulating effect on working capacity;**
- 2) **Adaptogens with influence on tissue metabolism;**
- 3) **Adaptogens – synbiotics with polyfunctional effect.**

Based on their composition and functional effect, the new bioproducts can be combined into modules for individual food prophylaxis and recreation regimes with various pathological conditions and disorders of the organism under the unfavourable factors during space flight and nervous psychic loadings along with the physical fatigue as a result of the training exercises by the ground control.

II. Technological approach

The new generation of space foods are technologically developed in accordance with new combined methods for technological processing -- multi stage cryobiotechnology with the following stages included:

- thermal treatment according to conventional methods → biotechnological processing
- enzyme immobilization + cell immobilization → fermentation processes → cryoprotection → freezing → freeze-drying.

III. Qualitative analysis of the new foods

Each product is tested in regard with the organoleptic, physicochemical, biochemical and microbiological parameters in compliance with standard methods for analysis.

Results and discussion:

Evaluation of the ingredient composition – from the medico-biological point of view, the ingredients of the new bioproducts from this module can be classified as follows:

- **structural ingredients** – cereals, nuts, fruits, fermented milk (sheep, goat, etc.);
- **energy ingredients** – fructose, honey, plant oils, polysaccharides;
- **ingredients with stimulating and regulatory function** – nutritive and

- curative plants – herbal extracts and substrates, oligosaccharides and microseaweeds – blue-green, red, brown etc; honey products – propolis, bee milk, enzymes, probiotic complexes of microbial cultures – lactic acid bacteria - **Lactobacillus bulgaricus, strain 3556, Lactobacillus acidophilus, strain 1379, Bifidobacterium bifidum, strain 1370, Streptococcus thermophilus, strain 1374, brewer's yeasts Saccharomyces cerevisiae, strains 577 and 1248** - have favourable effect in cases of **disbacterioses from various etiology, including professional bacterioses.**

These new bioproducts are 100 % natural foods without synthetic additives with plant extracts. Plants are substrates for oxidation as they maintain the acid balance, hormone balance, mediators, macro and microelements which improve the disintoxitaion function of the liver and the regeneration function of the nervous and endocrine systems due to the chemical composition [2,3].

The plant extracts are suitable for immobilization of useful microorganisms - probiotics of various origin and morphology. That's why the composition of the new functional foods contains oligo- and polysaccharides as a source of alimentary fibres, cryoprotectors and matrixes for immobilization of natural bioactive substances – probiotics and enzyme complexes of the new foods [4].

Organoleptic indicators – lyophilized products with fine consistency, pleasant aroma and taste properties specific for each product depending on its composition.

Chemical composition of the food lyophilized adaptogenes – series of “Synbiotics” (%/100g) : Proteins – from 8.67 to 15.30; Fats – from 17.00 to 28.00; Carbohydrates – from 60.73 to 63.50; Minerals from 3.45 to 4.90.

Active acidity (pH) of the lyophilized adaptogenes – series of “Synbiotics” varies from 5.0 to 5.7.

The residual moisture composition of all three bioproducts after lyophilization is low – from 1.98% to 3.45%. This allows to qualify these foods as high by concentrated foods.

The energy value (100 g) varies from 538.42 kcal (2252.76 kJ) to 583.48 kcal (2441.28kJ).

The mineral composition – average values of five repetitions from the obtained results are shown on Table 1.

As it is apparent from the Table 1 the new lyophilized functional foods from the series of “Synbiotics” are outlined with high composition of macroelements – phosphor, calcium, potassium, magnesium, sodium. This is due to the presence of

poly- and oligosaccharides – seaweed components, pectin, plant and vegetable extracts, brewer`s yeasts etc [1].

Table 1. Mineral composition of food adaptogenes – mg/100g

Product	P	Ca	Mg	K	Na	Fe	Mg
"Sb-Lyo-1"	443.90	522.30	51.80	780.00	247.00	2.66	0.06
"Sb-Lyo-2"	595.10	881.30	68.50	897.00	357.00	2.39	0.24
"Sb-Lyo-3"	1559.10	774.40	77.50	1913.00	628.00	7.59	0.21

Results from the biochemical analyses:

The new lyophilized food adaptogenes are characterized by high assimilation-95%. The total effect of the resultant proteolytic activity of the combined symbiotic starter cultures leads to a higher degree of coagulation of the whey and casein fraction of protein. In addition, the hydrolytic effect of enzyme proteases complex "attacks" mainly milk casein and at the same time increases its assimilation. These results were confirmed by the electrophoretic investigations conducted on the casein and whey proteins of the three types of synbiotics. The temperature treatment of the samples during lyophilization has no influence on the quantity of fractions related to the loss of electrophoretic mobility and their denaturation.

The need of the human organism of essential aminoacids is scientifically proved and complies with the composition of the standard "ideal" protein according to FAO. The biological value of the proteins of the new bioproducts is significantly higher compared to the standart protein according to FAO/WHO. The content essential aminoacids - lysine, isoleucine, leucine, valine, threonine and tryptophan in percent dose is significantly higher than in the standart protein. Their values in standart protein vary from 1.0 to 7.0 g/100 g protein whereas the composition in the new bioproducts is significantly higher up to 15.0% and 60.00% in leucine.

The chemical score of all aminoacids from the spectrum of the non-essential ones is above 100 - an indicator of their balance and high biological value. Furthermore, it is extremely important for the organism under extreme conditions of life and work to dispose of optimal proportion of the essential aminoacids close to that of the proteins in the human body. The proportion non-essential/total quality of aminoacids of the new foods is 55.60% higher than that of the standart protein -- 35.00% - an indicator of good aminoacid balance.

The biochemical analyses of the fatty acid composition of the new bioproducts have proved high content of free fatty acids. Free fatty acids are extremely important due to their rapid utilization during metabolism. Their formation provides half of the total amount of energy during metabolism [7]. In all three products, investigations have indicated high amount of free fatty acids and especially in the product “SB – Lyo-1” that proves the favourable effect of the double immobilization and particularly - the role of the hydrocolloid matrix, responsible for the cryoprotective properties for maintaining high lipolytic activity of the microbial lipase used during freeze-drying. Starter cultures have also lipolytic effect [6].

The results from the biochemical analysis of some of the main water- and fatty soluble vitamins in the new foods with adaptogene effect prove the relatively high content of provitamin A (β -carotene), vitamin E, watersoluble vitamins of group B and ascorbic acid – vitamin C that is due to the total effect of all ingredients of their composition. It is evident that the highest amount belongs to the vitamins with high antioxidant activity: *vitamin E*, ascorbic acid (vitamin C), β -carotene (provitamin A). The healthy effect of the new type of foods is determined by the composition of water soluble vitamins of group B – B₁ (thiamin) and B₂ (riboflavin). B₁ favours the assimilation of carbohydrates, facilitates the normal function of the nervous system, muscles and cardiovascular activity whereas riboflavin, in combination with other biologically active substances, provides for the assimilation of carbohydrates, proteins and fats, stimulates growth and prevents inflammatory processes.

The high concentration of bioactive substances, including vitamins as well, of the products of the series “Synbiotics” is a factor for their antioxidant activity, spectrophotometrically determined, on the basis of the total antioxidant capacity (radical scavenging activity), the so-called “TROLOX Equivalent” [5]. This indicator provides information about the overall content of antioxidants in the product of various origin and the synergic relations between them.

The results presented on Table 2 show the relatively high antioxidant activity of the functional foods with adaptogenic effect, measured by “TROLOX Equivalent”, and the value is close to that of the fresh fruits and some red wines – e.g. “Merlo”.

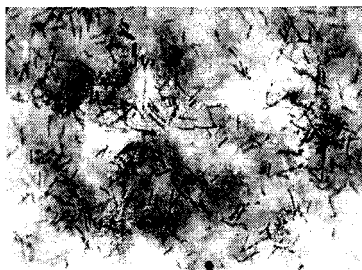


Table 2. Composition of some main antioxidants and radical scavenge activity of new adaptogenes – series of "Synbiotics"

Product	Ascorbic acid mg / %	Total carotenoides mg / %	Total Polyphenols mg/100g	Radical scavenge activity mmol TE/1000
"Sb-Lyo-1"	70.00	6.48	3700	81
"Sb-Lyo-2"	111.00	6.28	1300	115
"Sb-Lyo-3"	53.55	13.40	2000	169

Results from the microbiological investigations

The high antioxidant activity of the foods investigated with high concentration of useful microflora is $9.5 \times 10^8 - 9.5 \times 10^9$ after lyophilization, i.e. approximately 80.00% active living cells. This fact can be explained by the effect of the hydrocolloids used - oligo and polysaccharide matrixes. They allow the stabilization of the enzyme activity of immobilized cell and increase cells survivability after lyophilization and during storage. In addition, the bioactive substances in the composition have a favourable effect on the fermentation process.

The new functional foods have been investigated in accordance with standard indicators to detect pathogenic microorganisms. The results are presented on Table 3.

Table 3. Microbial status of food adaptogenes – series of "Synbiotics"

Type and amount of investigated microorganisms															
Total number of aerobic mesophilic microorganisms CFU/g Up to		Coliforms CFU/g		Clostridium CFU/g		Salmonella sp. in 25g		Staphylococcus aureus in 1g		Moulds CFU/g		Yeasts CFU/g		Lactic acid microorganisms CFU/g	
Noms	Analysis	Noms	Analysis	Noms	Analysis	Noms	Analysis	Noms	Analysis	Noms	Analysis	Noms	Analysis	Noms	Analysis
1000	250-510	should not be determined	not determined	should not be determined	not determined	should not be determined	not determined	should not be determined	not determined	100	10-25	100	25-45	10^6	10^6

As it is apparent from Table 3, the new foods contain no pathogenic microflora and comply with the standard requirements for microbial purity. The absence of pathogenic microorganisms proves that the whole technological process is conducted in accordance with the sanitary norms and requirements. The technology – freeze-drying has a bactericidal effect and suppresses the process of pathogenic microflora growth.

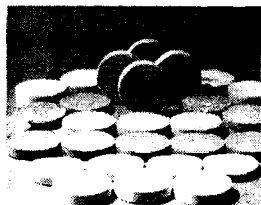
The technological, biochemical, physicochemical and microbiological investigations conducted lead to the following conclusions:

Conclusions:

1. The new synbiotic bioproducts with adaptogene effect, obtained according to modern cryobiology methods, show the high biological value and favourable physiological effect for bioprophylaxis against pathological conditions occurring during space flight and strenuous training exercises.

2. After lyophilization, the nutrition and biological value of the new food adaptogenes, created for space crew and ground control, is maintained in respect to the composition of the main nutrients and biogenic components. This allows us to determine the process as accurately programmed and conducted under optimal conditions.

3. The new biostimulants can be combined with other Bulgarian lyophilized functional foods with proved effect against obesity, hyperlipoproteinemias, cardiovascular disorders, osteoporosis, intestinal disorders etc. The innovative effect of our scientific investigations is based on the principally new methods for developing nutrition modules and biostimulants for individual nutrition regimes and programmes for astronauts.



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МОДУЛИ ОТ ХРАНИТЕЛНИ АДАПТОГЕНИ ЗА АСТРОНАВТИ И НАЗЕМНИ СЪСТАВИ

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Резюме

Установената причинна обусловеност и връзка между работоспособността и активността на космонавтите и тяхното хранене, обосновават необходимостта от създаване на подходящи биостимулиращи храни, под формата на комплекс от хранителни корегирани добавки.

На базата на високотехнологични методи са създадени два вида специализирани модула, включващи 6 вида нови лиофилизирани биостимуланти, богати на пълноценни протеини, есенциални аминокиселини, полиненаситени мастни киселини, растителни фибри, пробиотични комплекси, на антиоксиданти, витамини, микро-и макроелементи, на липотропни и други биоактивни вещества. Съчетани с подходящи български космически храни, разработени в института като първо българско космическо меню, новите биостимулиращи храни осигуряват по алиментарен път, ефективната биозащита на организма, поставен в екстремални условия на труд и бит, допринасят за поддържане висока ниво на жизненост, работоспособност и адаптивност на космонавтите, както и на наземните екипи по време на подготвително-тренировъчния период.