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APPLICATION OF CRYOTECHNOLOGY IN THE CREATION OF SPACE FOODS FOR CREWS WORKING IN EXTREME CONDITIONS

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Abstract

The article presents the achievements in the field of cryobiology and is related to the work for ESA project. Space food is a variety of food products specially formulated and processed for space flight use. Food should meet specific requirements to ensure balanced nutrition for those working in extreme conditions while being easily and safely stored, prepared and consumed in low gravity environments. It is reviewed domestic and foreign market for space foods and defined requirements to astronauts; for other users: military; extreme professions; extreme sports, for hospitals and children gardens. There are summarizes the nutritional requirements for all mentioned above group users of space foods. There is shown Bulgarian experience in research and development of space foods and comparison of the Bulgarian Space Menu.

Introduction

The intake of food is one of the most important physiological factors which is of decisive importance in sustaining the work capacity, adaptive powers and health condition of the astronauts during long space flights. The dominant negative factors encountered in the extraordinary labour and living conditions in space are weightlessness, high pressure, high radioactivity, peculiar microclimate, and great nervous and psychological stress, limited scope of movement, noise and vibrations, among others. The qualitative and quantitative sufficiency of the food is of crucial importance in helping astronauts cope with the negative processes underway in the organism under the influence of the adverse factors typical of long space flights.

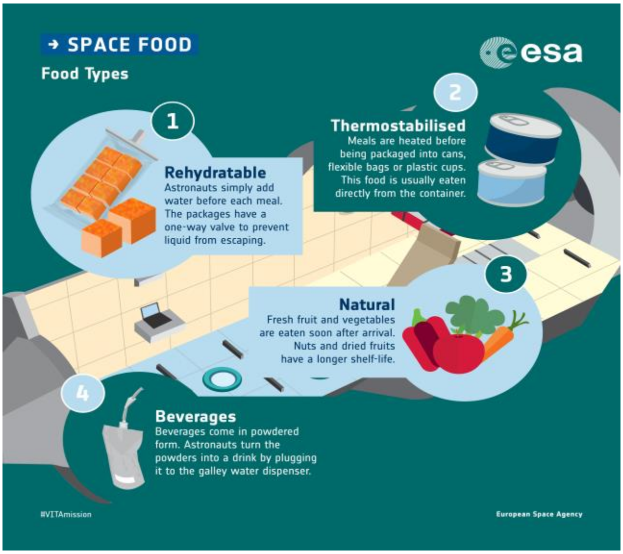
Space food is a variety of food products specially formulated and processed for space flight use. Food should meet specific requirements to ensure balanced nutrition for those working in extreme conditions while being easily and safely stored, prepared and consumed in low gravity environments. Despite the wide variety of food and beverages consumed by astronauts, it is very important that they are provided with a nutritional formula that provides all the necessary vitamins and nutrients and guarantees the working capacity and nervous psychological resistance of the crews [1–4].

The different forms in which food is provided include the following [5, 6]:

1. *Rehydratable* – both commercial and internally processed freeze - dried foods are included in the NASA food provisions and then rehydrated during the mission using the potable water supply. Rehydratable foods are typically side dishes, such as spicy green beans and cornbread dressing, or cereals. ESA rehydratable products include soups, shrimp cocktail and scrambled eggs fall into this category. Ambient and hot water are available to the crew for rehydration of these items.

2. *Thermostabilized* – this process, also known as the retort process, heats food to a temperature that renders it free of pathogens, spoilage microorganisms, and enzyme activity. NASA thermostabilized products include pouched soups, sides, desserts, puddings, and entrees. ESA thermostabilized products include beef with mushrooms, ravioli and tuna in this way.

3. *Natural form* – natural form foods are commercially available, shelf stable foods. The moisture of the foods may range from low moisture (such as almonds and peanuts) to intermediate moisture (such as brownies and dried fruit), but all have reduced water activity, thus inhibiting microbial growth. These foods help to round out the menu by providing very familiar menu options, additional menu variety, and foods requiring no preparation time.



4. *Beverages* – the beverages currently used on the International Space Station (ISS) are either freeze-dried beverage mixes (such as coffee or tea) or flavoured drinks (such as lemonade or orange drink). The drink mixes are weighed and then vacuum sealed inside a beverage pouch. In the case of coffee or tea, sugar or powdered cream can be added to the pouch before sealing. Empty beverage pouches are also provided for drinking water [7, 8].

5. *Extended shelf life bread products* – items, such as scones, waffles, tortillas, and dinner rolls, can be formulated and packaged to give them a shelf life of up to 18 months. Like the natural form foods, breads add to menu variety and address crewmembers' desire for familiarity.

6. *Fresh food* – foods such as fresh fruits and vegetables, which have a short shelf life, are provided on a limited basis, more for psychological support than as a means to meet dietary requirements.

7. *Irradiated* – irradiation is not typically used to process foods to commercial sterility. However, NASA has received special dispensation from the Food and Drug Administration (FDA) to prepare 9 irradiated meat items to commercial sterility (FDA 2009).

Space foods Bulgaria

The Institute of Cryobiology and Food Technologies and the Space Research and Technologies Institute in Sofia are pioneered biotechnologies for the production of space foods, offering a comprehensive menu known as the **Bulgarian Space Menu (BSM)** to the joint Soviet-Bulgarian space flights, within the framework of the *Shipka* project. As a result, the Republic of Bulgaria became the third country in the world, alongside Russia and the USA, to produce space foods [9, 10].

Bulgaria has experience and traditions in the development of freeze-dried foods and beverages designed for space crews and people's contingents working in extreme conditions.

Lyophilisation is a process of separation of moisture from fresh produce by vacuum and low temperatures, allowing virtually completely (to 95%) to be stored in these nutrients, vitamins, trace elements, even the original form natural flavour, taste and colour. Preserved by Lyophilisation product excludes the use of flavourings, colourings or preservatives. One of the most important advantages of this method is the small deformation of the initial product, which allows avoiding its destruction and restoring the original structure of freeze-dried products in cellular hydration. For long-term, safe and proper storage of food and organic foods that method is highly reliable and highly efficient. The high quality, convenience of storage and transportation leads to a widespread industrial development of the sublimation drying of food products. Major manufacturers of such foods are the United States, England, Canada, Denmark, France, China and others. The production list of most businesses includes fruit, vegetables, seafood, meat, poultry, eggs, mushrooms, tea, dairy products and ready-made culinary products. Over the last decade, cryobiotechnology enters more extensively in the manufacture of innovative products for the pharmaceutical, health, environment and other specific activities.

The BSM consists of 27 types of lyophilized foods based on meat, meat and vegetables and fruit and milk mixes; soups, main meals, desserts, Bulgarian yoghurt and fruit in the shape of quick meal and food pills. The pills are suitable for daily nutritional rations with a minimized mass of 300–500 g and a volume adapted to long space flights (Appendix1).

The BSM complies with modern nutritional requirements, with respect to composition and energy value, under extreme conditions during long space flights. The daily space food allowance of lyophilized foods has an energy value of 12 819 kJ /3 050–3 150 kcal/ and features the following chemical composition: proteins 135 g, fats 110 g, carbohydrates 380 g. The lyophilized space rations are rich in vitamins such as (3-carotene, A, the B complex, D, P, PP, C and others, mineral salts such as Na – 4.5g, K – 3.0 g, Ca – 0.8g, Mg – 0.4g, Fe – 0.05 g, P – 1.7g, organic acids, flavins, pectin substances, live lactic acid bacteria which play the role of detoxicants and regulators of the digestive tract.

The BSM is intended for a diet of four meals a day - two snacks, lunch and supper, with an interval between the meals of between three to five hours. Consumption of the lyophilized space foods is prescribed after rehydration, at temperatures between 27 to 65 °C /except the fruit/, depending on the type of foodstuff. The durability of the space foods extends to five years and they do not contain artificial preservatives.

The BSM is characterized by the delectable traditional flavour of Bulgarian cuisine, a high content of extracts, excellent organoleptic qualities assigned foods used in space conditions where sensory response is considerably subdued because of the change in the physiological activity of the sense of taste. The strong mix of flavour and taste of Bulgarian space foods contributes to the high rate of acceptance, good digestibility and favourable physiological impact on metabolism, adaptability, immune resistance and the work capacity of astronauts. At the same time, the Bulgarian space menu ensures a maximized diet free of dullness, providing for diversity in the daily menu of the astronauts in the course of protracted space flights.

The domestic and foreign market for space foods includes:

- Astronauts;
- Teams such as military, civil defence, firefighters, high rescuers, crew and others;
- Restorative infant feeding problems, mothers, students and athletes and other International market;

- Specialized hospitals to treat patients in the stages of medical evacuation, meals to troops operating in extreme terms.

- Extreme sports – mounting climbers, caving people and etc.

In addition to the above potential users of the innovative product markets are possible for crews working in conditions of prolonged space flight for the personnel of nuclear submarines, paratroopers, Special Forces, commandos and others.

Space Food's Requirements to Astronauts

Astronauts need the same number of calories during a spaceflight as they need on Earth. Fat, protein and carbohydrate provide energy to keep up their activities on the Space Station. Energy intake can differ for each person. The World Health Organization estimates energy requirements and issues recommendations based on a formula [11].

Energy equation*

MEN	WOMEN
1.7 (11.6W + 879) = X calories	1.6 (8.7W + 829) = X calories

** Per day for people 30-60 years old*
W= weight in kg

•A 80 kg man needs about 3000 calories a day
•A 60 kg woman needs about 2100 calories a day

Current ISS crew members receive about 1.8 kg of food plus packaging per person per day. Part of this food is thermostabilized, because the thermostabilized food is still generally preferred in taste tests to freeze dried items by crew members. Since the ISS utilizes solar panels for a power source and not fuel cells that produce water as a by-product, there is no mass advantage to using freeze-dried foods. Water is now transported to the ISS for rehydration. Furthermore, contributing to the mass increase is an increase in the required caloric delivery. The required calories as stated in the mission guidelines are based on the actual caloric needs of the crewmember, which are based on body weight and height. The result is an average caloric requirement of 3 000 kcal (12 550 kJ) as opposed to the 2 500 kcal (10 460 kJ) provided to the Apollo crew. In light of these mass challenges, NASA is considering various avenues of food mass reduction while still providing the crew with adequate calories and an acceptable diet [1].

Without adequate nutrition, human performance and sustainment are endangered. Adequate nutrition has 2 components – required nutrients and supplied energy in the form of calories. Distinct health issues stem from inadequate calories and from inadequate micronutrient intake. It is important that the crewmembers are provided with the required level of nutrition throughout their missions to prevent disease.

Table 1. Summarizes the nutritional requirements for long-duration missions

Nutrients	Daily dietary intake
Protein	• 0.8 g/kg and
	• ≤35% of the total daily energy intake and
	• 2 of 3 of the amount in the form of animal protein and 1 of 3 in the form of vegetable protein
PGCarbohydrate	50% to 55% of the total daily energy intake
Fat	25% to 35% of the total daily energy intake
Ω - 6 fatty acids	14 g
Ω - 3 fatty acids	1.1 to 1.6 g
Saturated fat	<7% of total calories
Trans fatty acids	<1% of total calories
Cholesterol	<300 mg/d
Fiber	10 to 14 g/4187 kJ
Fluid	• 1 to 1.5 mL/4187 kJ and
	• ≥ 2 000 mL
Vitamin A	700 to 900 µg
Vitamin D	25 µg
Vitamin K	Women: 90 µg
	Men: 120 µg
Vitamin E	15 mg
Vitamin C	90 mg
Vitamin B12	2.4 µg
Vitamin B6	1.7 mg

Nutrients	Daily dietary intake
Thiamin	Women: 1.1 mg
	Men: 1.2 mg
Riboflavin	1.3 mg
Folate	400 µg
Niacin	16 mg niacin equivalent
Biotin	30 µg
Pantothenic acid	30 mg
Calcium	1200 to 2000 mg
Phosphorus	• 700 mg and
	•·≤1.5 × calcium intake
Magnesium	• Women: 320 mg
	• Men: 420 mg and
	• ≤350 mg from supplements only
Fluoride	1 500 to 2 300 mg
Potassium	4.7 g
Iron	8 to 10 mg
Copper	0.5 to 9 mg
Manganese	• Women: 1.8 mg
	• Men: 2.3 mg
Fluoride	• Women: 3 mg
	• Men: 4 mg
Zinc	11 mg
Selenium	55 to 400 µg
Iodine	150 µg
Chromium	35 µg

The ability of the food system to meet the nutritional requirements can be determined only when the nutritional profile of the entire space food system is known for the time at which the food is consumed.

During the development of an extra-terrestrial food system, mission resources, including mass, volume, power, crew time, and waste disposal capacity, must be considered. Misuse of these resources could limit mission success. Consistently, the balance of resources with other necessary mission factors-food quality or crew hygiene – is at the forefront of planning and design. The conundrum of long exploratory missions is that these missions are both resource constrained and of long duration, requiring strict adherence to nutritional guidelines. Even though food and resource utilization may be at odds, both are vital to mission success. In short, the food must provide the nutrients to sustain crew health and performance, must be acceptable throughout the course of the mission, must be safe even after cooking and processing, and must be formulated and packaged in such a way that the mass and volume are not restrictive to mission viability.

Bulgarian potential customers except astronauts are Ministry of Defence, State Agency "Civil protection", Emergency Services, and other Specialized Hospitals.

Space Foods Requirements for other users

Foods Requirements for Military

The exact determination of the energy requirements of the military personnel is linked with the implementation of scientifically grounded approaches for calculation of the total energy requirement. Each vital, work or daily human activity is connected with consumption of energy, which is supplied by the organism by means of dissolving the received nutrient substances [12–14].

The average daily energy requirement of female and male servicemen with the same functional duties and analogical physical activities is shown at Table 2.

Table 2. Average daily energy requirement of female and male servicemen with the same functional duties and analogical physical activities

Physical activities	Duration of the research in days	Gender	Examined persons	Average daily energy requirement kcal/daily	Average daily energy requirement for 1 kg of the body weight kg.kcal-1.daily-1
Continued work during the training of Norwegian rangers	7	M	6	6 678	93.5
		F	4	5 597	95.7
Field training with intense physical loads	2.25	M	29	6 129	83.0
		F	20	4 727	82.0
Physical training	14	M	20	4 048	56.1
		F	10	2 378	41.1
Administrative activities	11	M	1	2332	38.7

Foods Requirements for sailors and submariners

Nutritional requirements of Navy Personnel are different from those of ground forces due to logistic constraints posed when being away from sea-coast.

Energy expenditure at ships was in the range of 2 449–4 907 kcal/day with a mean of 3 313 + 578 kcal/day, while in the case of submariners, it was 3 168 + 282 (2 606–3 907) kcal/day.

Energy intake in the case of sailors and submariners was not different either at hoer establishment and/or at ship/submarines. Energy intake was found to be 3518 + 286 kcal/day. The energy contribution from carbohydrates, fats and proteins was 59.9 per cent, 27.8 per cent, and 12.3 per cent, respectively (Table 3) [15].

Table 3. Nutrient intake of sailors and submariners

Nutrients	Intake
Energy (kcal)	3518 ± 286
Protein (g)	108 ± 25
Total Fat (g)	109 ± 24
Visible Fat (g)	68 ± 10
CHO (g)	527 ± 51
Vitamin A (μg)	625 ±102
Vitamin C (mg)	58 ± 22
Thiamin (mg)	1.7 ± 0.15
Riboflavin (mg)	1.6 ± 0.3
Niacin (mg)	33 ± 3.7
Iron (mg)	38.0 ± 6.6
Calcium (mg)	1410 ± 156
Phosphorus (mg)	1534 ± 125
Sodium (mg)	7000 ± 330
Potassium (mg)	2856 ± 135
Zinc (mg)	16.2 ± 1.30
Copper (mg)	2.80 ± 0.50
Energy contribution	
Carbohydrates per cent	59.9
Protein (per cent)	12.3
Fat (per cent)	27.8

Energy requirements for military personnel in extreme conditions

Energy requirements in hot climate. In areas of hot climate, a person is in a state of permanent heat pressure, especially during the summer months. When the temperature of the habitat is equal to or higher than the average temperature of the body surface, evaporation of sweat is the only way to maintain the body's thermal equilibrium. Calculations show that in similar conditions for the discharge of every 4.2 MJ (1 000 kcal) of metabolic heat from the body surface and upper respiratory tract, at least 1 725 g of moisture should evaporate. This moisture comes mainly through the sweat glands, which are able to secrete 10–12 and even up to 15 litters of sweat per day under heat stress conditions [16].

With many days of loss of large amounts of sweat (over 4–5 litters), the deficiency of mineral salts, especially potassium, and vitamins can be significant, which necessitates the correction of dietary rations to prevent salt depletion and devitaminization.

Energy requirement under hot climatic conditions

The analysis of the available literature imposes the conclusion, that generally the high temperature of the environment influences insignificantly on the daily energy requirements of the military personnel. A study, carried out in the desert shows, that the artillery units consume averagely 4 108 kcal/daily under average daily air temperature of 20.6 °C. Similar total energy requirements (3 941 kcal/daily) are observed for the infantry units in Israel, where the temperatures vary from 23 up to 31 °C. The Royal Australian Air Forces in North Australia consume about 3 702 kcal/daily, at temperatures varying from 24 to 33 °C, and the reformed tasks are linked with guard and transport support of an airport [17].

The comparison between the energy requirements of the artillery, of the infantry and of the ground units from the Air Forces show, that the general energy requirements are similar to the values, observed under cooler conditions (4 099 kcal/daily for training at the permanent dislocation station, 3 346 kcal/daily and 3 568 kcal/daily for everyday activities of the supporting units).

One of the reasons for that, roots in the fact, that the servicemen perform their obligations more efficient in hot, dry and clear days. The energy requirements are connected mainly with the sort and the duration of the activities, which are being performed, not with the hot meteorological conditions.

Energy requirements in winter and under cold climatic conditions

Hoyt and team consider that the general energy requirement of the military personnel increases in winter and under cold climatic conditions. In the examination of the American marines in cold weather (under temperatures of the environment from –10 up to 5 °C), average energy requirements of 5 398 kcal/daily are observed [18]. The general energy requirements had been around 4 156 kcal/daily in warm weather (under temperatures of the environment from 9 up to 31 °C) for the same course at the same place, under analogical general physical and mental pressure.

Energy requirements in the highlands

It is recommended to provide personnel operating in the mountains with a diet containing up to 4 500 kcal (about 17 MJ). With regard to the qualitative composition, then, given the difficulties of metabolizing fat and partially proteins, they provide an increase in the carbohydrate quota, and preference is given not to one of them, but to their mixtures.

The servicemen from the American Army, located in Potosi, Bolivia at 3 500–4 050 m altitude, have had an average daily energy requirement of 3 535 kcal, 10 days long, during the construction of the infrastructure [94]. These values are a little bit higher than the general energy requirements of 3 463 kcal/daily for servicemen from the engineering units, performing similar activity at a sea area.

Requirements for extreme professions

Civil protection crews. On-board emergency packages

Designed to provide rescue professional emergency services, professional emergency rescue units for civil defence, emergency situations and disaster relief when on board a ship in an emergency. The diet is a set of canned and concentrated foods per person per day and consumed with the permission of the ship's commander in case of accidents (Table 4).

Table 4. The Following Products are Included in the Food Ration

Products	Weight(g)
Bread (biscuits) army of wheat flour 1 grade	150
Canned meat-cereal and meat-vegetable	500
Food concentrates briquetted, not requiring cooking	120
Or Food concentrates briquetted for instant cooking	120
Condensed whole milk with sugar	90
Or chocolate paste	50
Or dry milk	70
Or dry milk drink	70
Sugar	15
Lollipop	20

Products	Weight(g)
Or sugar	40
Or fruit stick	50
Or fruit jam	60
Instant coffee	2
Black tea	2
Multivitamins, coated tablets	2
Plastic spoon, (pcs).	1
Can opener, (pcs)	1
Drinking water, canned , (ml)	125

Food And Energy Value of Food Ration – proteins 83 g; fats 92 g; carbohydrates 348 g, Energy Value – 2 552 kcal.

Requirements for fire brigade crews

This study piloted the use of an electronic activity monitor (MTI AM 7164-1.2) as a tool for estimating activity (EE(ACT), kcal day^{-1}) and total (EE(TOT) kcal day^{-1}) energy expenditure in wildland fire fighters during extended periods of wildland fire suppression. Ten Hot Shot fire fighters (9 men, 1 woman) volunteered to wear a MTI monitor during every work shift for 21 consecutive days. Summarizing whole-body motion data each 1 min, the raw activity data (counts min^{-1}) were transformed into units of kcal min^{-1} using a custom computer program with standard conversion equations. EE(TOT) averaged (Mean ± SD) 4 768 ± 478 kcal day^{-1}, while EE(ACT) averaged 2 585 ± 406 kcal day^{-1}, neither of which differed significantly (P = 0.198 and 0.268, respectively) from literature values reported for Hot Shots using the doubly labelled water technique. These data suggest that the electronic activity monitor provided reasonable estimates of EE in wildland fire fighters. This study should be verified, however, with a more complete validation methodology to ensure these findings [19].

Requirements for extreme sports

Caving peoples

The impact of caving activity on body composition and hydration were assessed through bioelectrical impedance, and nutritional habits of cavers surveyed. During cave activity, measured total energy expenditure (TEE) was in the range 225 ± 287 kcal/h for women-men (MET = 4.1), respectively; subjects had an energy intake from food in the range 1 000 ± 1 200 kcal, thus inadequate to restore lost calories.

Comparison of dietary intake and energy expenditure (TEE) in a normal day versus the full cave day and cave activity per se, offers interesting cues (Table 5).

Table 5. Anthropometric measurements, physiological variables, and dietary intake

	Men		Women	
	Mean	SD	Mean	SD
Height (m)	1.7	0.1	1.6	0.1
Weight (kg)	73.2	11.7	55.4	6.0
BMI	24.7	3.0	21.8	2.1
TEE (kcal/24h), normal day	3487.9	528.2	2367.3	316.6
TEE (kcal/24h), cave day	5128.5	862.5	3980.9	441.1
TEE (kcal/h), cave activity	287.5	48.5	225.4	27.9
MET's, cave activity	4.1	0.7	4.1	0.5
Intake (kcal/24 h), normal day	2640.7	673.5	1858.1	324.3
Intake (kcal/24 h), cave day	3393.7	1530.3	2672.9	732.3
Intake (kcal/10 h), cave activity	1186.8	473.4	1008.2	513.2

BMI, body mass index; MET, metabolic equivalent of task; TEE, total energy expenditure; SD, standard deviation.

Requirements for children gardens and hospitals

The physiological norms of nutrition of the population

Lyophilized space foods can also be used to feed the population based on physiological nutrition norms.

Energy needs are defined as mean energy needs expressed in MJ and kcal per day for population groups age-differentiated by reference height and weight estimated for different levels of physical activity and representing the average daily requirement over a period of at least one week.

The application of the physiological norms of nutrition aims at meeting the physiological needs, achieving normal growth and development and creating prerequisites for long-term good health of the population [20].

Table 6. Average energy needs for boys and girls from 1 to 19 years of ageby age groups

Age (years)	Boys		Girls	
	MJ/daily	кcal/daily	MJ/daily	кcal/daily
1 – <3	4.36	1 040	4.09	980
3 – <5	5.66	1 350	5.26	1 260
5 – <7	6.80	1 630	6.32	1 510

Age (years)	Boys		Girls	
	MJ/daily	**кcal/daily**	**MJ/daily**	**кcal/daily**
7 – <10	7.55	1 800	7.07	1 690
10 – <14	9.92	2 370	9.35	2 230
14 – <19	13.12	3 130	10.35	2 470

Table 7. Average adult energy needs

Age (years)	Body weight (кg)	Height (cm)	Low active lifestyle MJ (кcal)/daily	Moderately active lifestyle MJ (кcal)/daily	Active lifestyle MJ (кcal)/daily	A very active lifestyle MJ (кcal)/daily
	Men					
19 – <30	70	178	9.81 (2 344)	11.21 (2 679)	12.61 (3 013)	14.0 (3 348)
30 – <60	72	176	9.56 (2 286)	10.93 (2 612)	12.29 (2 939)	13.66 (3 265)
60 – <75	79	173	8.66 (2 070)	9.90 (2 365)	11.13 (2 661)	
75 +	68	171	8.47 (2 024)	9.68 (2 314)		
	Wimen					
19 – <30	56	164	7.65 (1 828)	8.74 (2 089)	9.83 (2 350)	10.93 (2 612)
30 – <60	60	164	7.63 (1 823)	8.72 (2 083)	9.80 (2 343)	10.89 (2 604)
60 – <75	60	160	6.99 (1 672)	7.99 (1 911)	8.99 (2 150)	
75 +	55	158	6.70 (1 600)	7.65 (1 829)		
	Pregnancy and nursing**					
Pregna-ncy	Trimester		I	+ 0.29 (+ 70)		
				+ 1.09 II (+ 260)		
			III	+ 2.09 (+ 500)		
Nursing	Month		0 – 6	+ 2.09 (+ 500)		

The main customers of lyophilised products are mountaineers and athletes who need long-term shelf-life foods. And when they have gone through this freezing and drying, they last up to 5 years and more. Recently, consumers of this recipe are also vegetarians.

The Bulgarian Space Menu was highly praised and appreciated by the members of the Himalayan expeditions, the Transatlantic Women's Regatta, the two expeditions to the Antarctic and on many other occasions.

Conclusion

Taking into account the most common requirements, our potential customers and our long-standing experience in developing freeze-dried foods at this stage, we are continuing to study the trends in space-based food development.

The aim of the ESA project is the development and implementation of technology for astronauts and various contingents of people working in extreme conditions. This project will definitely contribute to the development of science and practice in the particular scientific field. Products developed under this project will contribute to improving the efficiency of contingent working in extreme conditions. At the same time the results of the experiments will serve as the basis for new theoretical and experimental research in cryobiology and contribute to its development.

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ПРИЛОЖЕНИЕ НА КРИОТЕХНОЛОГИЯТА ПРИ СЪЗДАВАНЕ НА КОСМИЧЕСКИ ХРАНИ ЗА ЕКИПАЖИ, РАБОТЕЩИ В ЕКСТРЕМНИ УСЛОВИЯ

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Резюме

Статията представя постиженията в областта на криобиологията и е свързана с работата на авторите по проект с ЕКА. Космическата храна е разнообразие от хранителни продукти, специално създадени и обработени за използване в космически полети. Тази храна трябва да отговаря на редица специфични изисквания, за да може да осигури балансирано хранене за работещите в екстремни условия, като същевременно лесно и безопасно се съхранява, приготвя и консумира в среда с ниска гравитация. Направен е преглед на вътрешния и чуждестранен пазар на космически храни. Определени са изискванията към астронавтите, както и за други потенциални потребители: военни; хора с екстремни професии; за екстремни спортове, за болници и детски градини. Дадени са обобщени хранителни изисквания за всички споменати по-горе групи потребители на космически храни. Показан е българският опит в изследването и разработването на космическите храни и създаденото българско космическо меню.