UDC 66.047; 664.8/9; 355.65; 796

DEVELOPMENT OF THE FOOD PRODUCTS INDUSTRY FOR INDIVIDUALS WITH INCREASED PHYSICAL ACTIVITY

https:// doi.org/ 10.15673/fst.v20i1.3363

L. Avdieieva, Doctor of Sciences, senior researcher
A. Makarenko, Candidate of Sciences, senior researcher
Institute of Engineering Thermophysics of Ukraine National Academy of Sciences,
Marii Kapnist St., 2a, Kyiv, Ukraine, 03057

Correspondence:

A. Makarenko
E-mail: tbds_ittf@ukr.net

Cite as Vancouver style citation

Avdieieva L., Makarenko A. Development of the food products industry for individuals with increased physical activity / Food Science and Technology. 2026;20(1):13-27. https:// doi.org/ 10.15673/fst.v20i1.3363

Цитування згідно ДСТУ 8302:2015

Avdieieva L., Makarenko A. Development of the food products industry for individuals with increased physical activity // Food Science and Technology. 2026. Vol. 20, Issue 1. P. 13-27. https:// doi.org/ 10.15673/fst.v20i1.3363

Abstract. The global food industry for individuals exposed to increased physical activity is experiencing rapid growth. In Ukraine, this issue is particularly relevant for the nutrition of military personnel and athletes, who are constantly subjected to significant physical and psycho-emotional stress. Nutritional challenges for people with high physical activity levels, including athletes and military personnel, are multifactorial and relate to the specifics of the basic diet, the nature of physical exertion, and the need to meet elevated energy expenditures. Analysis of numerous studies by domestic and international researchers indicates that an effective way to satisfy the increased nutritional needs of such individuals is the additional consumption of dietary supplements of various compositions and functional purposes. Growing demand stimulates further development of production and the creation of innovative technologies for products and supplements of different types and functional targets, making this field highly relevant and continuously evolving. The aim of the research was to analyze the current state and development trends of the food products industry for individuals with increased physical loads, including athletes and military personnel. Current classifications of sports nutrition differ between countries, but overall the market is highly diverse and includes the production of protein powders, sports drinks, energy bars, protein-carbohydrate products, as well as various functional and energy supplements. Protein powders and their derivatives maintain the highest demand and occupy the largest market segment in recent years. Carbohydrate and protein-carbohydrate complexes are also widely popular. A significant share of products comprises supplements intended to support recovery from muscle, joint, and bone injuries. Innovations focus on developing new specialized formulas to satisfy rapidly expanding dietary needs and wellness goals, improving systems for delivering bioactive compounds, increasing nutrient absorption, and enhancing bioavailability.

Keywords: health nutrition, sports nutrition, military nutrition, proteins, protein hydrolysates, biologically active substances, protein-vegetable concentrates.

Introduction. Formulation of the problem

Nutrition is one of the most important environmental factors influencing the human body throughout life. The food industry is constantly evolving. Adequate nutrition, combined with sufficient fluid intake, significantly affects the body's immune defenses and is essential for the normal functioning of all body systems. In recent years, due to the deteriorating state of the natural environment and the associated decline in quality of life, increasing attention is being paid worldwide to the relationship between diet and health disorders. The role of adequate nutritional and energy support becomes particularly important under conditions of increased physical and psycho-emotional stress, during which the demand for nutrients with high biological and nutritional value increases significantly, as these are rapidly depleted. Prolonged deficiency of such substances may cause irreversible harm to the body in the long term [1-3].

In Ukraine, the issue of nutrition is most acute for military personnel and athletes. The physical and psycho-emotional stress placed on the bodies of military personnel in combat zones and on athletes during training and competition is significantly higher than that experienced by ordinary individuals in their daily activities. All metabolic processes occur more intensively, requiring a greater intake of appropriate nutrients and energy [4, 5]. At the current stage of sports development, it has been established that the organization and control of a rational diet allow for higher athletic achievements. Therefore, this factor

occupies one of the priority positions in the athlete training system. This approach not only enables athletes to reach optimal performance levels, but also promotes effective recovery, reduces the risk of injuries, immune system disorders, decreased bone mineral density, and the onset of symptoms associated with overtraining syndrome [4, 6]. Nutrition is also an important factor for military personnel. Metabolic disturbances caused by a diet that does not meet physiological standards under conditions of military service are one of the most common causes of reduced performance and increased general morbidity. Experience from local armed conflicts shows that casualties with musculoskeletal injuries account for a significant proportion of total casualties of military personnel. The importance of nutritional quality becomes even greater during rehabilitation treatment (inpatient or outpatient stage) for the recovery of combat veterans [7–11].

An effective way to meet the increased nutritional needs of athletes and military personnel is supplementary nutrition, including in the form of dry powder food concentrates with high energy, nutritional and biological value of a defined composition, in the form of dietary supplements of various functional targets. Dry concentrates may be particularly important for individuals with limited access to fresh food products. The advantages of dry concentrates include increased nutrient concentration, high nutritional value, convenient storage and preparation conditions, as well as an extended shelf life [12, 13].

Analysis of recent research and publications

Nutrition has a profound impact on the performance and overall well-being of professional athletes. Athletes must follow a balanced diet adapted to their specific nutritional needs. For this reason, athletes are required to systematically maintain a certain body weight while simultaneously ensuring adequate intake of macronutrients and micronutrients. Balanced nutrition plays an important role in maintaining physical activity, improving athletic performance, and facilitating recovery after training. In this regard, the diet must be carefully planned and scientifically justified, taking into account the athlete's weight category, the period and stage of sports training, the nature of physical loads, the volume and intensity of training and competition workloads, the level of athletic mastery, the individual characteristics of the digestive system, dietary habits and preferences, and must be free of doping substances. To supplement their diet and achieve specific training goals, many athletes additionally consume dietary supplements of various compositions and functional targets. Such supplements cover a wide range of possibilities, addressing nutrient deficiencies with regard to age, improving recovery, stimulating muscle synthesis, boosting energy levels, and optimizing performance [1, 4, 14].

The daily energy expenditure of modern individuals is significantly lower compared to the past, which means that dietary patterns are primarily characterized by a substantial reduction in the energy value of the daily diet. This leads to a significant deficiency in the consumption of micronutrients essential to the body, which reduces the body's resistance to harmful environmental influences ("maladaptation"), causes immunodeficiency states, and impairs the functioning of antioxidant defense systems. A situation has arisen where resolving the problem of unbalanced nutrition in modern individuals through the classical approach alone – namely, the application of rational nutrition principles – has become unrealistic. The term "healthy nutrition" (HN) is used in the practice of WHO experts. The implementation of healthy and health-promoting nutrition (HPN) systems among the population will contribute to reducing the incidence of lifestyle diseases and increasing life expectancy. According to the WHO Global Strategy on Diet, Physical Activity and Health, physical activity is the primary means of improving both physical and mental health of individuals. Thus, beyond the category of professional athletes, the popularity of a healthy lifestyle is growing worldwide, leading to increased demand for specialized sports nutrition products among the general population. Today, fitness is one of the most popular forms of physical activity. In Ukraine, some attention is given to the development of scientific foundations of nutrition and the assessment (monitoring) of the population's nutrition of its specific groups. Nutritional monitoring is used to justify dietary standards for various population groups (including professionals, athletes, children, adolescents, elderly persons, etc.), sets of food products, obtaining statistical data on actual nutrition of the population and its specific groups, and for monitoring dietary contaminants, etc. Unfortunately, such studies have not yet become sufficiently widespread with regard to the nutrition of athletes and fitness practitioners [15, 16].

Of extremely important significance is the alignment of increased physical loads and the diet of military personnel. For military personnel to effectively carry out their current tasks and maintain an optimal level of physical and mental performance, nutrition that is adequate in terms of energy expenditure, quality and quantity is required, as well as adequate hydration. Nutrition is an important factor that contributes to accelerating the treatment of the wounded, their recovery and rehabilitation. When addressing this issue, the body's nutrient requirements at various stages must be taken into account – during military training, participation in military operations, hospital treatment, the rehabilitation period, and others. Due to recent events in the world and in Ukraine, the military and medical implications of military personnel's nutrition have become the subject of extensive research and investment [5, 9, 17, 18].

Currently, the market offers a wide variety of sports nutrition products, including sports drinks, shakes, gels, bars, and dry powder supplements. The sports nutrition industry is rapidly developing and has significant prospects for market expansion, production technology advancement, and increased investment. However, it also faces many challenges, such as the lack or insufficiency of innovation and scientific research, as well as safety risks and concerns. Research on athletes' nutrition is quite popular in both domestic and international science. The importance of providing effective dietary recommendations for athletes is emphasized. However, most of them are predominantly general in nature and do not account for such important factors as actual daily energy expenditure, individual athlete requirements for macronutrients and micronutrients, body composition characteristics, weight categories, dietary preferences, and many others [19, 20].

Thus, the nutritional challenges for individuals with increased physical activity, including athletes and military personnel, are multifactorial, related to the characteristics of the basic diet, the nature of physical load and corresponding energy expenditure, availability of drinking water, taste preferences, and many others. All of the above factors highlight the great relevance of research and development projects aimed at developing scientifically justified technologies for the production of concentrated functional multicomponent food products and beverages of a defined physicochemical composition. Such products can be used as a complete dietary supplement for individuals with increased physical activity to support and accelerate recovery.

The aim of the research is to analyze the current state and development trends of the food products industry for individuals with increased physical activity, including athletes and military personnel, and to identify priority directions for the development of technologies for domestic products with enhanced nutritional value, enriched with functional ingredients.

Research materials and methods

Analytical research on modern technologies and food products for individuals with increased physical activity, including athletes and military personnel. Leading scientific publications included in the PubMed, Google Scholar, Scopus and Web of Science databases for recent years in this field were used to conduct the research.

Results of the research and their discussion

The growing popularity of sports and an active lifestyle, along with increasing consumer interest among health-conscious individuals in the role of nutrition in restoring physical energy, immune defenses, and improving mental health, has in recent years led to active demand for a special group of products — sports nutrition products. Sports nutrition is one of the most actively developing segments of the functional food and dietary supplement market.

Sports nutrition is typically consumed as a dietary supplement. Its nutritional value and component composition differ significantly from conventional food products. The nutritional components of sports nutrition can generally be divided into two categories: basic nutrients and functional components. Basic nutrients include proteins, fats and carbohydrates, or their metabolites, required by the human body for full development and as an energy source. Functional components refer to active or functional ingredients of animal and plant origin, such as glucosamine, curcumin, L-carnitine and lycopene [1, 21, 22].

Sports nutrition provides balanced nutrition to meet the metabolic and energy needs of people engaged in sports. Today, there is no doubt about the important role that nutrition plays in sports. Moreover, nutrition must be adapted to the specific type of sport and many other factors. Over the past 20 years, the number of studies identifying the relationship between sports and diet for athletes of different sports disciplines, age groups, and training stages has increased several times over. As a result of rapid growth, the sports and sports nutrition industry has reached a new level and represents a fully-fledged sector of the economy. The range of sports nutrition products is constantly expanding, with new product types emerging, including products for athletes labelled "halal", "kosher", etc. [16, 19, 23, 24].

In recent years, the range of sports nutrition products has changed significantly. The global market has expanded beyond the category of nutrition for professional elite athletes and is experiencing a phase of rapid growth. This is driven by the rapid increase in the number of consumers choosing an active lifestyle. Nutrition is becoming increasingly adapted to specific activity patterns, training goals, and recovery needs. This market encompasses the production of protein powders, sports drinks, energy bars, protein-carbohydrate products, various functional and energy supplements, and many others. The sports nutrition market is continuously growing to meet a wide range of expanding dietary needs and wellness goals [4, 23, 24].

In the majority of countries, there is no clear classification of special-purpose food products, including sports nutrition. Current classifications of sports nutrition differ between countries depending on the needs of athletes for sports nutrition products to achieve optimal results in the development of specified physical qualities. The European Union classifies sports nutrition products into sports drinks, food products, and supplements. In Canada, sports nutrition is additionally classified into two categories depending on the target audience: athletes (competitive athletes and amateurs) and individuals pursuing a healthy lifestyle. In the United States, the classification of sports nutrition products is more diverse and includes products such as

energy drinks, weight loss meal replacements, dietary supplements, and low-carbohydrate products. In China, sports nutrition is divided into six categories: energy supplements, energy control supplements, and protein supplements, as well as by type of physical load: speed-strength sports categories, endurance-dominant sports categories, and post-workout recovery categories. In Ukraine, depending on the intended purpose, the following groups of sports nutrition are distinguished: for muscle building, for weight loss, for increasing the intensity and duration of training, for preventing joint damage, for general body strengthening, and others [21, 25–27].

Conventionally, most classifications are based on the product's purpose and composition. The global sports nutrition market is segmented by product type (sports protein products, sports non-protein products), source of origin (animal or plant-based), distribution channel (supermarkets, pharmacies, online stores, etc.) and geography (North America, Europe, Asia-Pacific, South America, Middle East and Africa) [22].

Depending on the product composition, all food mixtures and preparations for sports nutrition are divided into macronutrients and various biologically active food supplements. Macronutrients include basic nutrients and their metabolites required by the human body, which include proteins, carbohydrates and lipids. The following product groups are produced for sports nutrition: protein, carbohydrate, protein-carbohydrate, carbohydrate-mineral preparations and mixtures, additionally containing biologically active substances — vitamins, polyunsaturated fatty acids, plant extracts, and others [1, 16, 19, 21].

In terms of sales channels, online retail stores hold the leading position in the global sports nutrition market. In 2025, sales through this channel accounted for 38.4%. Annual growth of this segment is projected at 10.76% through 2030 [22].

Geographically, North America and Europe are the leading consumers of sports nutrition products, accounting for 61.2% in 2024, with projected annual growth of 2.1% driven by government and institutional support for fitness and wellness programs. The Asia-Pacific region is forecast to be the fastest-growing region in terms of demand through 2030, with an average growth rate of 10.03%. In China, despite the later establishment of the sports nutrition industry, the sector is developing at a rapid pace. Developed countries currently lead this market owing to their longer history of sports nutrition adoption and development with government-level support, with the United States holding the leading position [21, 22].

The share of protein supplements and their derivatives in sports nutrition is the largest, which is due to the ability of proteins of plant and animal origin to help the human body maintain skeletal muscle mass. It has been established that increased protein intake leads to a positive muscle protein synthesis response and even long-term improvement in muscle mass. Protein supplements are most commonly produced in dry powder form. While the recommended protein intake for a non-athletic adult is 0.8 g per kg of body weight per day, for athletes these requirements increase significantly — from 1.2 to 2.0 g/kg body weight/day, depending on the sport. The amount is calculated in accordance with the training stage to prevent possible muscle catabolism, repair of exercise-induced muscle damage, improve metabolic adaptation, and others [28, 29].

Thus, protein powders and their derivatives have maintained the highest demand and occupied the largest market segment in recent years. The share of these products in the sports nutrition market in 2024 was 82.14% [22].

The use of protein mixtures in sports nutrition is a very broad field, encompassing proteins of animal and plant origin, their hydrolysates, peptides and amino acids. These preparations are distinguished by their effect on the body: improving sports performance, increasing energy, reducing body fat mass, supporting muscle strength, promoting muscle protein synthesis, restoring muscle mass, and others [1, 4, 20, 30].

Protein products are designed to provide the human body with sufficient dietary protein, helping to maintain muscle mass and physical performance. The interaction between physical activity and nutritional elements is key in regulating muscle protein synthesis and breakdown. Skeletal muscles undergo constant regulation, therefore during physical exercise it is necessary to ensure adequate consumption of protein and essential amino acids to establish a balance between muscle protein synthesis and breakdown. The amount, timing and type of protein intake affect the degree of muscle recovery after training. The protein source in protein products includes proteins of animal origin (whey, purified meat protein, etc.) or plant origin (soy, rice, wheat, flaxseed, etc.), although whey protein and casein are the most common components of protein products [29 – 31].

The biological value of protein is most often assessed by measuring the efficiency with which a given protein is absorbed and utilized. According to the corrected amino acid digestibility score (PDCAAS) on a scale from 0 to 100, animal proteins are considered complete, as they contain all essential amino acids in sufficient quantities with a digestibility score of 77 to 100. Their inclusion in the diet ensures a comprehensive intake of complete protein. Plant proteins typically lack or are deficient in some essential amino acids, particularly lysine and methionine, which requires their additional combination with other protein sources to achieve the required amounts according to the needs of the human body. The digestibility of plant proteins ranges from 56 to 74, with the exception of soy protein, which scores 100 [28, 29].

The biological value, digestion rate and digestibility are significantly influenced by the protein processing

method used in the production of protein preparations. Processing methods such as dispersion and heat treatment — hydromechanical, hydrodynamic, ultrasonic, high-pressure homogenization, drying methods, and others — used in the production of high-quality long-shelf-life protein products cause varying degrees of protein denaturation and may lead to significant changes in their digestibility behavior [33–35].

By source of origin, animal-based protein products hold the largest market share — 63% in 2025 — while demand for plant-based proteins is growing rapidly, particularly among young consumers, with a projected growth rate of 9.7% annually through 2030. Manufacturers are responding to changing consumer preferences by increasing innovative development of plant-based protein product segments that combine personal health improvement goals with a positive environmental impact. The segment of products combining animal and plant proteins is also growing, allowing the advantages of each to be combined for improved exercise performance and post-workout recovery. This trend highlights the great potential for innovative development of combined protein products. A rapid increase in product offerings with balanced taste profiles, the required level of energy, nutritional and biological value, and at the same time a moderate environmental impact is expected [22].

Protein hydrolysates are a type of protein mixture containing peptides of various molecular weights and free amino acids. They are produced by enzymatic or acid hydrolysis, which allows varying degrees of protein hydrolysis to be obtained. Due to the complex production technology, they have a higher cost (three times more expensive than protein concentrates or isolates). Protein hydrolysates have significant advantages over protein mixtures: a high degree and rate of absorption, rapid replenishment of muscle glycogen stores and post-workout recovery, compared to isolated and concentrated protein preparations. When comparing the anabolic properties of individual free amino acids and protein hydrolysates, it was found that mass gain occurred faster when using hydrolysates of complete protein. Nitrogen retention and glutamine concentration in muscles were also higher, as was the ability to stimulate insulin secretion, and allergenicity was lowest [30, 34, 36–39].

Amino acid complexes are sports nutrition supplements that serve as a source of easily digestible protein. Amino acids are the structural components of proteins, and their purpose is to supply the body with protein broken down into individual amino acids for rapid absorption. The main roles of amino acid complexes in sports include: accelerating recovery; boosting metabolism; effective fat burning; suppression of catabolic processes (which negatively affect muscle growth); prevention of mental fatigue, and others. Amino acid complexes are distinguished by a higher price compared to protein shakes, while offering significant advantages in terms of convenience of consumption.

The anabolic effectiveness of amino acid complexes is influenced by the content, quantity and ratio of non-essential and essential amino acids in the product. For example, it has been established that leucine, alanine and proline improve the muscle's ability to recover, enhance endurance and muscle mass in combination with whey protein and carbohydrates. Tryptophan increases serotonin levels in the brain, which raises pain tolerance during high-intensity training, among other effects. Arginine is one of the conditionally essential amino acids that positively influences the elimination of metabolic waste from the body and the secretion of growth hormone (GH), also known as somatotropin. Arginine may also improve blood supply to muscles by regulating cardiovascular tone [40].

However, the effectiveness of amino acid supplementation as popular sports supplements has been debated, as their impact on sports performance varies across different sports disciplines, and due to the ambiguity of clinical trials. The development of precise amino acid complex formulations tailored to the needs of specific sports is considered a promising direction [40].

BCAA (branched-chain amino acids) is a complex of three essential amino acids with branched chains: leucine, isoleucine and valine. BCAA are typically supplied in capsules, but may also be available in liquid form and powders. The main functions of BCAA for an athlete include: prevention of catabolism and muscle protein synthesis, increased fat burning through the activation of hormones responsible for this process, and an increase in nitrogen balance, the positive values of which are a prerequisite for building skeletal musculature [40–42].

A significant segment of sports nutrition is occupied by supplements for recovery from muscle, joint and bone injuries. Regular participation in strength sports can lead to problems with joints and the ligamentous system. Nutrition, through its influence on the overall physical and psychological condition of an athlete, plays a significant positive role in injury prevention, improving recovery processes and tissue healing.

Muscle injuries are among the most common sports injuries. In particular, special attention is paid to the consumption of amino acids and proteins, antioxidants, creatine and omega-3 fatty acids due to their therapeutic role in preventing muscle loss and anabolic resistance, as well as promoting injury healing. For faster recovery, reduction of muscle loss and acceleration of the healing process during injury, an increase in protein intake to 2.3 g/kg body weight/day is recommended, especially in combination with physical exercise during the rehabilitation process [43–45].

When selecting proteins, the presence and content of individual amino acids in the composition must be

taken into account. In recent years, researchers have found that branched-chain amino acids (BCAA) increase anabolism and reduce catabolism of muscle proteins. Altered protein metabolism during physical exercise may reduce damage to myofibrillar proteins and disruption of muscle fibers [46].

Given that leucine is one of the key elements of protein synthesis, it is often included in supplements for recovery from muscle injuries. It promotes anabolic stimulation by overcoming resistance to protein synthesis [47, 48].

The positive effects of creatine supplementation have been demonstrated, including improved strength, increased muscle mass, and assistance in faster muscle recovery during physical exercise. Creatine may also be beneficial in reducing muscle atrophy in athletes during immobilization following injury [49].

Dietary supplements for joint and ligament recovery include collagen supplements and supplements that support collagen synthesis, such as gelatin and vitamin C. Collagen is rich in glycine, proline, hydroxylysine and hydroxyproline, and the consumption of these amino acids increases collagen synthesis and improves the structure of ligaments and tendons. Animal studies have demonstrated that collagen hydrolyzed to peptides significantly enhances collagen biosynthesis, stimulates regulation of the collagen cycle in cartilage tissue, and improves the size and composition of collagen fibrils in tendon cells [50, 51].

Gelatin has an amino acid content similar to that of collagen; its consumption enhances collagen production in the body and promotes cartilage tissue recovery [52, 53].

The composition of supplements in this category also includes micronutrients that specifically target the aforementioned tissue types — chondroitin sulfate, glucosamine sulfate and calcium.

Ensuring adequate calcium intake in combination with vitamin D plays a significant role in optimal bone formation during fracture healing. It has been demonstrated that supplementation with 800 IU/day of vitamin D and 2000 mg of calcium reduces the risk of stress fractures in female Navy recruits. Other nutrients supporting metabolic processes important for bone tissue include iron, zinc, silicon, vitamin A, vitamin K, as well as vitamins C and B. However, excessive consumption of micronutrients during injury recovery remains a subject of debate [54–56].

Fat burners are a specific type of sports nutrition product that promote body weight reduction. Their main mechanism of action is based on processes that reduce fat content in adipose cells through: accelerating metabolism, suppressing appetite, and accelerating the elimination of fluids from the body. The main and most common components of fat burners include: caffeine, L-carnitine (which also has a positive effect on cognitive abilities), polyunsaturated fatty acids (omega-3), dopamine (the hormone responsible for the sense of satisfaction), green tea, capsaicin, ginger, and others. The components of these preparations are permitted for use in the food industry, however the results of clinical studies regarding their effectiveness in stimulating weight loss are currently considered inconclusive [57–60].

Energy supplements are a complex of substances that enhance the activity of the brain and cardiovascular system. They are produced in the form of drinks or gels. Their purpose is to stimulate the nervous system to achieve specific sports results and to rapidly restore energy after intense training. Energy drinks (ED) can improve acute aerobic exercise performance, which largely depends on the caffeine content (more than 200 mg per drink or more than 3 mg per kg of body weight). Energy drinks with high or low caloric content typically contain caffeine, taurine, ginseng, guarana, carnitine, choline, B vitamins (vitamins B1, B2, B3, B5, B6, B9 and B12), vitamin C, vitamin A (beta-carotene), vitamin D, electrolytes (sodium, potassium, magnesium and calcium), tyrosine, and others. According to scientific data, the primary energy-generating nutrients in most drinks are caffeine and carbohydrates. Products with high glycemic load, caffeine and/or other stimulants are not recommended for consumption by children under 12 years of age, adolescents under 18 years of age, diabetics, and individuals with comorbid cardiovascular and other diseases [61, 62].

Mass gainers are protein-carbohydrate mixtures in which proteins and carbohydrates can be distributed in various ratios, most commonly 20:80. The primary purpose of mass gainer consumption is to achieve the fastest possible rate of muscle mass gain, increase the daily caloric intake of the diet, and restore the body's energy reserves after intense physical exercise. Mass gainers enjoy stable consumer demand [26, 29].

The carbohydrates (60–80%) present in mass gainers may be fast-absorbing (e.g., glucose and fructose) as well as slow-absorbing (starches). The carbohydrate composition of mass gainers also frequently includes sucrose, maltodextrin, or complexes of mono-, di- and polysaccharides. Proteins (15–40%) are most commonly represented by whey proteins and casein, as well as their mixtures with plant-based proteins. Occasionally, individual amino acids, enzymes, creatine, vitamins and minerals are additionally included in the composition [20, 30].

The consumption of carbohydrates in combination with protein or essential amino acids during various types of training, primarily endurance and strength training, may have beneficial effects, including improved anabolic hormonal status, reduced muscle damage, increased muscle cross-sectional area and increased time to exhaustion [63].

To achieve high sports results, consumption of the basic macronutrients is sufficient. However, in addition to nutrient intake, some sports disciplines require the consumption of specialized dietary supplements to complement the diet, which positively influence the

improvement of endurance, overall physical fitness, and sports performance. This category of supplements typically includes: creatine monohydrate, caffeine, arginine, glutamine, sodium bicarbonate, and others. These supplements should be prescribed individually, according to the needs of each person (sex, age, physical fitness, intensity and duration of exercise, etc.) and the goal set (maintaining health, improving physical condition). The use of such supplements must be supported by a sufficient level of scientific evidence confirming their action, and must offer the highest possible quality and safety [26, 64–66].

Minerals and Vitamins. Their purpose is supplementary vitamin and mineral nutrition. They are produced in the form of capsules, powders, liquids or injections. Vitamins are directly involved in metabolism in the human body, and metabolism is the basis of vital activity, which is particularly relevant for improving the speed-strength performance characteristics of the body. Certain vitamins directly affect the quality of digestion; in their absence, the body will simply be unable to deliver beneficial substances to target organs or synthesize them at all. The most important functions in the body are performed by: vitamin C — supports immunity under conditions of intense training; B vitamins — participate in metabolism across many pathways; vitamin D — essential for the prevention of musculoskeletal disorders; vitamin K — required for normal blood clotting; vitamin E — supports body recovery.

With regard to minerals important for sports nutrition, this category includes substances such as calcium, phosphorus, iron, sodium and magnesium. All of these are present in food, however with an active lifestyle, the need for them increases significantly. The use of vitamin-mineral complexes for athletes must correspond to the intensity, duration and nature of physical exercise [67, 68].

Sports Drinks. During intense prolonged physical exercise, athletes may require additional hydration and sodium intake in amounts corresponding to their individual physiology, but typically consume insufficient amounts of fluid and electrolytes immediately before and during training and competition. Sports drinks are primarily used for rehydration and replenishment of necessary electrolytes and other important components for athletes, such as magnesium, sodium, calcium, potassium, glucose and fluid lost during intense physical exercise, to enhance endurance and performance. They are typically consumed during intense physical exercise, allowing sports performance to be improved and fatigue to be delayed. Sports drinks usually contain purified water, carbohydrates, inorganic salts, vitamins and other fatigue-reducing substances such as L-carnitine, caffeine, and others. The typical components of an isotonic sports drink are a combination of carbohydrates (glucose and maltodextrins) and electrolytes (particularly sodium). The recommended carbohydrate range for sports drinks is 6 to 8%. Innovations and the development of specialized formulas are stimulating the growth of the energy gel segment — semi-solid supplements designed to supply the body with nutrients before, during or after activity. Energy gels are characterized by their versatility and allow for rapid replenishment of the body's energy [19, 69, 70].

An important factor of healthy nutrition is the regular consumption of fruits and vegetables. Consumers demand products with natural or plant-based ingredients and a balanced formulation composition. There is a clear relationship between the pursuit of a healthy diet, increased consumption of fruits and vegetables, and reduced fat intake. Inadequate consumption of plant-based foods is associated with insufficient intake of macro- and microelements, carbohydrates, including pectins and dietary fiber, vitamins, and a range of bioactive phytochemicals, including phenolic compounds such as anthocyanins, ellagitannins, resveratrol and quercetin [71–74]. Plant components are incorporated into sports nutrition, primarily in the form of extracts, with the aim of improving training adaptation, performance, and recovery. Studies have been presented concerning the potential effectiveness of using whole fruits and vegetables, their parts, or extracts: apples, blackcurrants, grapes, cherries, watermelon, and others. Studies of the antioxidant capacity of various vegetables demonstrated that the highest antioxidant capacity and phenol content were found in Chinese mint buds, lemon verbena, perilla leaves, cowpea, caraway, lotus root, sweet potato leaves, green soybeans, pepper leaves, ginseng leaves, chive, and broccoli [74]. Results demonstrated that fruit by-products may serve as an important, inexpensive, and readily accessible source of biologically active compounds for use in the food and pharmaceutical industries [73]. Most athletes most frequently fail to reach the recommended intake of fruit and vegetable raw materials due to the complex coordination of training activities and food consumption, taste preferences, unavailability, inconvenience of consumption, or difficulties with digesting large quantities of plant fiber. Due to digestive issues, an increasing number of athletes have begun consuming fruits and vegetables in the form of supplements — fruit and vegetable concentrates or extracts. The results of many studies confirm the need to develop appropriate additional dietary recommendations and epidemiological research [74, 75].

Functional complexes with a balanced mixture of vitamins, minerals, phytonutrients, and other bioactive substances formed by combining various fruit and vegetable raw materials can lead to additive and synergistic interactions in human metabolism, which have a positive effect on the health of the organism. Consequently, combining a greater number of such raw materials in a single supplement exceeds in

effectiveness the use of a supplement containing only vitamins, phytochemicals, juice or powder from only one or several fruits and/or vegetables. The emergence of functional ingredients that improve bioavailability and consistency creates a transition of the sports supplement market toward high-quality healthy food products that supply the body with beneficial substances and satisfy the diverse needs of consumers [19, 76].

Innovations in the production of sports nutrition with a high content of biologically active substances, including dietary fruit and vegetable supplements, focus on the selection of complex ingredient combinations and modern delivery systems, the use of methods for preserving antioxidant activity and stabilization, as well as improving nutrient absorption. One of the tools for creating modern delivery systems is the use of the spray-drying method for liquid multicomponent heterogeneous systems. Spray drying is currently the most widely used method of encapsulation of bioactive substances, as it belongs to high-speed and high-performance controlled methods and is used for drying a wide range of materials, including thermosensitive substances. With appropriate selection of the composition and concentrations of composite wall materials based on polysaccharides and proteins, such as dextrins or milk proteins, this method allows high-quality microcapsules to be produced. The spray-drying encapsulated material has improved functional properties: solubility, stability of bioactive substances during storage, and controlled release characteristics in vitro to facilitate its unobstructed passage through the intestine, thereby increasing bioavailability. These features suggest the use of spray-drying microencapsulation for the creation of functional food products; however, additional research is required to ensure low toxicity of the composites and improved bioavailability [35, 77, 78].

Deficiency of important dietary nutrients in athletes' nutrition can lead to excessive production of reactive oxygen and nitrogen species, causing damage to cell tissues, increased frequency of inflammatory processes, reduced immunity, increased susceptibility to injury, and increased recovery time. Athletes striving to achieve peak performance face the challenge of managing oxidative stress, a natural by-product of cellular metabolism and physical exercise. A moderate level of this indicator is an integral part of training adaptation; however, severe or sustained oxidative stress can cause cellular damage, inflammation, and impede recovery. Therefore, athletes and researchers recognize the growing importance of optimizing nutritional strategies for regulating oxidative stress, which can lead to enhanced performance and reduced risk of overtraining-related issues. As a result, natural antioxidants are playing an increasingly important role in supporting cellular resilience and improving overall health, particularly in individuals engaged in intensive physical exercise, such as sport [71, 72, 76].

Natural antioxidants from plant materials are primarily polyphenols (phenolic acids, flavonoids, anthocyanins, lignans and stilbenes), carotenoids (xanthophylls and carotenes), and vitamins (vitamins E and C). Natural antioxidants are predominantly obtained from food and medicinal plants, such as fruits, vegetables, cereals, mushrooms, beverages, flowers, spices and traditional medicinal herbs. Furthermore, the industry processes agricultural by-products of fruits and vegetables (peel, pomace, seeds), which are also potentially important sources of natural antioxidants [73, 74, 79].

Over the past few decades, the plant-based sports dietary supplement industry has expanded significantly due to the availability of phytochemicals obtained from leaves, bark, berries, roots, gums, seeds, stems or flowers of plants, predominantly in the form of extracts. Herbal preparations are popular dietary supplements due to their content of phytochemicals, such as polyphenols, terpenoids, glycosides, alkaloids, saponins, and other substances that have positive physiological effects on the human body and are beneficial to health. Worldwide, the use of herbal phytopreparations is regulated by food and drug control authorities as a special category of food products. In sports nutrition, phytochemical plant additives are used to stimulate physiological or metabolic responses that may improve exercise performance, muscle mass gain, stimulate weight or fat loss, increase energy levels and nervous system activity, mental concentration, and so on. Numerous plant-based supplements are marketed as ergogenic aids for athletes. Such active ingredients include: ginseng, guarana, maté, ginger, caffeine, and many others [80–82].

Caffeine is an alkaloid most commonly used as an ergogenic agent. Caffeine is found in many plants. This ingredient is one of the most widely used supplements in sports nutrition. The numerous benefits of this product in sports practice are well known: improved performance, enhanced endurance and alertness, and improved cognitive function. It is available in the form of dried roots, as well as in capsules, energy drinks, energy gels, aerosols, energy bars, chocolate, confectionery, chewing gum, and others [83–85].

Ginseng is one of the most popular plant-based dietary supplements, long used for medicinal and dietary purposes. It is one of the most extensively studied agents for increasing physical activity, enhancing endurance and stimulating brain function by attenuating the catabolic effect of the stress hormone cortisol. Its anti-inflammatory and antioxidant effects have been demonstrated. Ginseng contains numerous important biologically active compounds, such as vitamins (A, B, C and E), minerals (iron, magnesium, potassium and phosphorus), dietary fiber, proteins, saponins and a large number of various types of ginsenosides. Ginseng has side effects that are significant and must be taken into account when

selecting the dose. In sports nutrition, it is one of the popular herbs used to support the body under stress conditions, improve physical activity and athletic performance, and increase endurance, but it has notable limitations. It is available in capsules, powder, compressed tablets, energy drinks, energy gels, energy bars, confectionery, and chewing gum [86, 87].

Guarana - known as guarana gum – is quite frequently used due to its content of alkaloids: caffeine, theophylline, theobromine, tannins and saponins. According to the Natural Medicines database, guarana contains a greater amount of caffeine than most plants, ranging from 3.6% to 5.8% caffeine compared to 1% to 2% in coffee. Guarana has been found to have a positive stimulating and cognitive effect, activating the central nervous system, increasing resistance to fatigue, and improving body weight [88, 89].

Green tea extract (GTE) is one of the important plant-based supplements recently used in sports nutrition products to prevent weight gain. It contains a greater amount of caffeine, as well as polyphenols (catechins, theobromine and theophylline), which have antioxidant properties and increase energy expenditure by stimulating brown adipose tissue thermogenesis. Green tea extract supplementation has been found to enhance endurance, improve the antioxidant defense system and lipid oxidation in muscles, and reduce exercise-induced oxidative DNA damage [86, 90, 91].

Ginger contains a large number of phenolic compounds – gingerols, shogaols, paradols, gingerdiones and terpenes and their analogues — which exhibit anti-inflammatory properties and inhibit pain receptors. For this reason, in sports nutrition ginger is promoted as a natural analgesic, as well as an agent that promotes glycogen maintenance in skeletal muscles by enhancing fat metabolism. It is available in the form of powder or extracts [92–94].

Capsaicin (CAP) is the primary pungent bioactive ingredient of pepper varieties such as cayenne, red and chili. The effect of CAP triggers a powerful neuronal calcium influx, often accompanied by a reflex reduction in TRPV1 (transient receptor potential vanilloid 1) activity. For this reason, CAP is a promising clinical tool for modulating TRPV1-related pathways. The United States Pharmacopeia has classified capsaicin as a stimulant, meaning its consumption can trigger sympathetic activation of the central nervous system, increasing catecholamine secretion and enhancing lipid oxidation, conserving glycogen utilization, increasing resistance to fatigue, and thereby improving exercise performance. However, studies on the effect of capsaicin on carbohydrate metabolism during physical exercise remain limited [95, 96].

Cordyceps sinensis (CS) is an ascomycete fungus belonging to the family Clavicipitaceae and the order Hypocreales. It is used in traditional Chinese medicine to treat a variety of conditions, including fatigue, respiratory and renal diseases, renal dysfunction, and cardiac dysfunction. Its effective therapeutic action in reducing cholesterol levels and immune system disorders has been demonstrated. Cordyceps sinensis, the most widely used species of Cordyceps as a supplement, is mass-produced and sold under the name Cs-4. In athletes, CS has been shown to stimulate greater endurance and increased hemoglobin levels following supplementation (5 days at a dose of 100–150 mg/kg) with greater aerobic capacity. CS extract supplementation (in powder form) may increase muscle resistance to fatigue by enhancing lactic acid production, improve cardiovascular response, heart rate variability and blood pressure during maximal exercise testing. Available studies using Cordyceps vary considerably in dosage and duration of supplementation. However, high doses of CS may cause stomach upset and diarrhea, therefore it is important to determine a safe dose and duration of intake [86, 97].

Cystoseira canariensis is a species of brown seaweed that has attracted researchers' attention for use in the production of sports preparations. It is proposed as an agent for increasing muscle mass and reducing body fat by inhibiting myostatin, a muscle growth factor, particularly in the context of promoting muscle growth. Studies have demonstrated that extracts of this seaweed may be potentially beneficial for athletes and individuals seeking to increase muscle mass. The standard therapeutic dose of Cystoseira canariensis is approximately 1200 milligrams per day, typically divided into three intakes; however, other researchers have been unable to confirm such results [80].

In Ukraine, the share of sports nutrition products and supplements from domestic manufacturers, compared to the share of imported goods, remains negligible. This is due to the absence of government support programs and state funding for the development of health food production. Production is characterized by a limited product range, low compliance with modern consumer needs, and a shortage of high-quality domestic raw materials [16, 20].

Research and studies on the clinical efficacy of various types and components of sports nutrition are finding increasing application in the development of new product types in all armies of the world, including for military personnel of the Armed Forces of Ukraine. Studies examining the prevalence, use factors, and side effects have shown that dietary supplements associated with sport are very frequently consumed by US Army military personnel. It has been established that military personnel consumed various types of sports nutrition at least once a week over the previous 6 months. Studies conducted showed that almost half of military personnel consumed soy unsaturated products on a weekly basis. The consumption of sports nutrition by military personnel is not associated with sex, age, marital status, officer status, a greater number of weekly aerobic or strength training sessions, or other factors. The conclusions noted that the number of side effects from

consuming various types of sports nutrition was comparatively low [98–102].

In recent years, many countries have significantly increased military expenditure, primarily due to geopolitical instability in several regions and the potential risk of armed conflicts spreading worldwide. In this context, understanding the nutritional needs of military personnel under various climatic conditions (warm, cold, or high-altitude), as well as depending on the type and intensity of physical load, are important factors that directly affect the performance and health of soldiers, particularly under extreme conditions [98, 99, 103]. For Ukraine, currently under martial law, taking into account the specifics of multifactorial effects on the bodies of military personnel is of the utmost importance. The nutrition of Armed Forces of Ukraine military personnel significantly affects the state of the body's defense mechanisms and is of great importance for the normal functioning of all body systems. This is especially true for military personnel currently stationed in combat zones. Metabolic disturbances caused by a diet that does not meet physiological standards under conditions of military service are one of the most common causes of reduced performance and increased general morbidity among military personnel. The amount of fluid, calories, macro- and microelements contained in military rations must be determined taking into account the type of physical load, duration and environmental conditions. Military rations, in addition to being nutritionally adequate, must be practical, environmentally sound, and easy to consume at any temperature and in any situation. The development of military rations is becoming a key factor in meeting the nutritional needs of soldiers in various operational contexts, contributing to their ability to maintain maximum performance. In addition to a long shelf life and stability, due to environmental conditions and the specifics of task execution, a military ration must also be lightweight (e.g., freeze-dried products) and quick to prepare and consume under extreme conditions. Thus, ease of consumption, packaging and ease of preparation are of great importance for the development of an adequate military ration [7, 8, 98, 99, 103].

During training exercises and combat operations, significant body mass loss occurs due to stressful environmental conditions (cold, heat and high altitude). Loss of glycogen and associated water, loss of fat and subsequent loss of muscle mass during combat operations result from altered protein kinetics and contribute to catabolism, which impairs the performance of military personnel. The protein requirement also increases for repair of muscle fibers and enhancement of metabolic activity. Increased protein intake is of critical importance for preventing undesirable reduction in skeletal muscle mass over time [103, 104].

During prolonged physical activity of military personnel, the need for carbohydrates and water increases (the requirement depends on the degree of physical activity during the execution of combat tasks). In this case, carbohydrates also serve as the most important source of energy for the body and are particularly important for enabling maximum work capacity of skeletal muscles. With prolonged deficiency of these macronutrients, the body's performance can rapidly decline [104–106]. The high physical and psycho-emotional loads encountered by military personnel in the execution of service and combat tasks lead to a significant increase in the body's need for essential substances such as vitamins and minerals. These issues remain a subject of concern and stimulate ongoing research in the field of military personnel nutrition [11, 98, 102, 107].

As a result of relevant analytical research, the authors established that the existing food rations for military personnel of the Armed Forces of Ukraine comply with modern physiological standards in terms of energy value and are not inferior to those of foreign counterparts; however, analysis of their composition revealed the absence of dairy products, vegetables, fruits, and dishes for vegetarians. To diversify the rations, the use of products with enhanced nutritional value, enriched with functional ingredients, is proposed [104].

Thus, the scientific developments and technologies for sports nutrition products and supplements and military nutrition share a common goal – to provide the body with the necessary nutritional and energy substances for optimal functioning under conditions of increased physical and psychological loads. Research by Western scientists shows that military personnel in general consume many dietary supplements. It has been established that 25–50% of military personnel consume sports drinks, sports bars and energy gels. Thus, it is advisable to consider including such products in military rations for training and combat operations. This is particularly important for ensuring the consumption of the required amounts of micronutrients and vitamins, which cannot be easily incorporated into traditional field rations due to their instability (oxidation, thermal denaturation, etc.) and processing challenges [98, 100].

Conclusion

1. The sports nutrition industry is developing rapidly and dynamically worldwide, driven by the growth of professional sport and an expanding consumer base seeking a healthy lifestyle. In response to increased consumer demand, sports nutrition has become a fast-growing category of health food, with forecasts of sustained growth in the coming years. Developed countries lead this market owing to appropriate government programs and institutional support for fitness programs at the state level. This field is becoming highly relevant for Ukraine as well, stimulating the development and implementation of new domestic innovative technologies.

2. The nutrition factor is particularly acute for military personnel. The physical and psycho-emotional loads placed on their bodies are significantly higher than those experienced by ordinary individuals in everyday activities. Scientific research and development have demonstrated that products and supplements for sports nutrition and military nutrition share a common goal — to provide the body with the necessary nutritional and energy substances for optimal functioning under conditions of increased physical and psychological loads.

3. An effective way to meet the increased nutritional needs of athletes and military personnel is the supplementary consumption of food products and concentrates of various compositions with high energy, nutritional and biological value in the form of supplements of various functional targets. A rationally composed dietary regimen is one of the most important factors for maintaining high physical activity, improving the condition of the body, and facilitating accelerated recovery.

4. The sports nutrition market encompasses the production of various types of protein powders, sports drinks, energy bars, protein-carbohydrate products, various functional and energy supplements, and many others.

5. Innovations focus on developing new specialized formulas to satisfy a wide range of growing dietary needs and wellness goals, identifying effective delivery systems for biologically active substances, and improving nutrient absorption and bioavailability.

6. In the majority of countries, there is no clear classification of sports nutrition products. Current classifications differ between countries and depend on the needs of athletes to achieve optimal results. Most classifications are based on the product's purpose and composition. In Ukraine, depending on the intended purpose, the following groups of sports nutrition are distinguished: for muscle building, for weight loss, for increasing the intensity and duration of training, for preventing joint damage, for general body strengthening, and others.

7. By product composition, components can be divided into two categories: basic nutrients (macronutrients) and functional factors. The main product groups are: protein, carbohydrate, protein-carbohydrate, carbohydrate-mineral preparations and mixtures, mixtures containing carbohydrates and polyunsaturated fatty acids, and others. Protein powders and their derivatives have maintained the highest demand and occupied the largest market segment in recent years.

8. An important factor of healthy nutrition is the regular consumption of fruits and vegetables, which contain a large number of biologically active substances. An increasing number of athletes have begun consuming fruits and vegetables in the form of supplements — fruit and vegetable concentrates or extracts. Such supplements supply the body with beneficial substances, satisfy the diverse needs of consumers, and have improved bioavailability and consistency.

9. Over the past few decades, the plant-based sports dietary supplement industry has expanded significantly due to the availability of phytochemicals obtained from leaves, bark, berries, roots, gums, seeds, stems or flowers of plants. Such plant-based supplements are used for building muscle strength, weight or fat loss, increasing nervous system activity, mental concentration, and so on. These include: ginseng, guarana, maté, ginger, caffeine, and many others.

10. The development of military rations is becoming a key factor in meeting the nutritional needs of soldiers for the normal functioning of all body systems. Research by Western scientists shows that military personnel in general consume many dietary supplements (sports drinks, sports bars, energy gels, etc.). It is advisable to include such products in military rations for training and combat operations. This is particularly important for ensuring the consumption of the required amounts of micronutrients and vitamins, which cannot be easily incorporated into traditional field rations due to their instability (oxidation, thermal denaturation, etc.) and processing challenges.

11. Based on the conducted analysis, priority directions for the development of domestic specialized food products for individuals with increased physical activity have been identified. A promising direction is the creation of multicomponent concentrates with enhanced nutritional and biological value, enriched with functional ingredients — protein hydrolysates, fruit and vegetable components, and natural biologically active substances — that will ensure support and accelerated recovery of the bodies of athletes and military personnel.

References:

1. Arcusa Saura R, Zafrilla Rentero MP, Marhuenda Hernández J. Sports nutrition and performance. In: Mózsik G, Figler M, editors. Nutrition in health and disease – our challenges now and forthcoming time. London: IntechOpen; 2019. Chapter 7. https://doi.org/10.5772/intechopen.84467
2. Bremner JD, Moazzami K, Wittbrodt MT, Nye JA, Lima BB, Gillespie CF, et al. Diet, stress and mental health. Nutrients. 2020;12(8):2428. https://doi.org/10.3390/nu12082428
3. Firth J, Gangwisch JE, Borsini A, Wootton RE, Mayer EA. Food and mood: how do diet and nutrition affect mental wellbeing? BMJ. 2020;369:m2382. https://doi.org/10.1136/bmj.m2382

4. Amawi A, AlKasasbeh W, Jaradat M, Almasri A, Alobaidi S, Hammad AA, Bishtawi T, Fataftah B, Turk N, Saoud HA, Jarrar A, Ghazzawi H. Athletes' nutritional demands: a narrative review of nutritional requirements. Front Nutr. 2024;10:1331854. https://doi.org/10.3389/fnut.2023.1331854
5. Hill N, Fallowfield J, Price S, Wilson D. Military nutrition: maintaining health and rebuilding injured tissue. Philos Trans R Soc Lond B Biol Sci. 2011;366(1562):231–240. https://doi.org/10.1098/rstb.2010.0213
6. Holway FE, Spriet LL. Sport-specific nutrition: practical strategies for team sports. J Sports Sci. 2011;29(Suppl 1):S115–S125. https://doi.org/10.1080/02640414.2011.605459
7. Deputat YM, Rychka OV, Horishna OV, Zhaldak AY. Assessment of servicemen's health as one of the stages of nutrition standardization. Ukrainian Journal of Military Medicine. 2022;3(2):25–36. https://doi.org/10.46847/ujmm.2022.2(3)-025 (in Ukrainian).
8. Tovma LF. Improving the quality of therapeutic nutrition for servicemen in hospital and field conditions. Scientific Journal «ScienceRise». 2017;(2(31)):12–15 (in Ukrainian).
9. Goyko IY, Simakhina GO, Stetsenko NO. Prevention of protein deficiency in servicemen's diets. Scientific Works of NUHT. 2015;21(6):197–203 (in Ukrainian).
10. Avdieieva LY, Makarenko AA, Dekusha GV. Specialized high-protein nutrition to improve treatment and rehabilitation conditions of wounded servicemen. Actual issues of providing activities of bodies and units of the Ministry of Internal Affairs system with technical means in martial law conditions: Collection of abstracts of the II All-Ukrainian scientific-practical conference (Kyiv, April 25, 2024). Kyiv: DNDI of the Ministry of Internal Affairs of Ukraine; 2024. p. 57–60 (in Ukrainian).
11. Lenferna De La Motte KA, Schofield G, Kilding H, Zinn C. An alternate approach to military rations for optimal health and performance. Mil Med. 2023;188(5-6):e1102–e1108. https://doi.org/10.1093/milmed/usab498
12. Arslan A, Alibaş İ. Assessing the effects of different drying methods and minimal processing on the sustainability of the organic food quality. Innov Food Sci Emerg Technol. 2024;94:103681. https://doi.org/10.1016/j.ifset.2024.103681
13. Thakur, C., Kaushal, M., Vaidya, D. et al. Unlocking the Potential of Spray Drying for Agro-products: Exploring Advanced Techniques, Carrier Agents, Applications, and Limitations. Food Bioprocess Technol 18, 1181–1220 (2025). https://doi.org/10.1007/s11947-024-03544-4
14. Mkrtchan EV, Hruzevych IV, Kropta RV. Dietary support for the training of athletes specializing in mixed martial arts. In: Development of physical culture and sports amidst martial law: conference proceedings, October 5–6, 2022. Częstochowa, Republic of Poland: Baltija Publishing; 2022. p. 32. https://doi.org/10.30525/978-9934-26-253-1-32
15. Tsyhanenko OI, Khomenko IM, Maslova OV, et al. Wellness Nutrition for People Practicing Fitness. In: Tsyhanenko OI, editor. Kyiv: Shchek; 2021. 240 p. (in Ukrainian).
16. Prytulska NV, Koshelnyk AV. Assortment policy of sports nutrition manufacturers in Ukraine and worldwide. Visnyk of Lviv University of Trade and Economics. 2018;20:41–47 (in Ukrainian).
17. Hulich MP, Deputat YM, Liubarska LS. Nutrition of servicemen of the Armed Forces of Ukraine under the conditions of the Joint Forces Operation: problems and comparative assessment of individual food rations. Military Medicine of Ukraine. 2019;19(1):46–51 (in Ukrainian).
18. Sotelo-Díaz I, Blanco-Lizarazo CM. A systematic review of the nutritional implications of military rations. Nutrition and Health. 2019;25(2):153–161. https://doi.org/10.1177/0260106018820980
19. Prytulska NV, Antiushko DP, Motuzka YuM. Current trends in the sports nutrition market. Food Science and Technology. 2012;1(18):49–52. (in Ukrainian).
20. Avdieieva LYu, Dekusha HV, Turchyna TY, Makarenko AA. Features of the composition of gainers as a relevant type of sports nutrition. Scientific Works. 2024;88(1):43–49. https://doi.org/10.15673/swonaft.v88i1.2958 (in Ukrainian).
21. Cui P, Li M, Yu M, Liu Y, Ding Y, Liu W, Liu J. Advances in sports food: Sports nutrition, food manufacture, opportunities and challenges. Food Research International. 2022; 157: 111258. https://doi.org/10.1016/j.foodres.2022.111258
22. Sports Nutrition Market Size & Share Analysis – Growth Trends & Forecasts (2025-2030) [Internet]. Mordor Intelligence. Available from: https://www.mordorintelligence.com/industry-reports/sports-nutrition-market
23. Thomas DT, Erdman KA, Burke LM. American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. Medicine and Science in Sports and Exercise. 2016;48(3):543–568. https://doi.org/10.1249/MSS.0000000000000852
24. McArdle WD, Katch FI, Katch VL. Sports and Exercise Nutrition. 9th ed. Philadelphia: Wolters Kluwer; 2019. 657 p.
25. Kruchanytsia MI, Myroniuk IS, Rozumykova NV, Kruchanytsia VV, Brych VV, Kish VP. Fundamentals of Nutrition: textbook. Uzhhorod: UzhNU "Hoverla" Publishing House; 2019. 252 p. (in Ukrainian).
26. Melnikov A, Shynkaruk V, Hishchak O. Speed and strength abilities of kickboxers and means of their development. Young Scientist. 2023;12(124):54–59. https://doi.org/10.32839/2304-5809/2023-12-124-17 (in Ukrainian).
27. Maidaniuk OV, Vdovenko NV. Nutrition of qualified athletes in endurance sports. Scientific Journal of the Ukrainian State University named after Mykhailo Drahomanov. Series 15: Scientific and pedagogical problems of physical culture (physical culture and sport). Kyiv: Publishing House of the Ukrainian State University named after Mykhailo Drahomanov; 2024;(3K(176)):301–304. (in Ukrainian).
28. Moore DR, Soeters PB. The biological value of protein. In: Meier RF, Reddy BR, Soeters PB, editors. The Importance of Nutrition as an Integral Part of Disease Management: 82nd Nestlé Nutrition Institute Workshop; 2013 Oct; Gurgaon, New Delhi. Basel: S. Karger AG; 2015. p. 39–51. https://doi.org/10.1159/000382000
29. Berrazaga I, Micard V, Gueugneau M, Walrand S. The role of the anabolic properties of plant- versus animal-based protein sources in supporting muscle mass maintenance: a critical review. Nutrients. 2019;11(8):1825. https://doi.org/10.3390/nu11081825
30. Avdieieva LYu, Dekusha HV, Zhukotskyi EK. Enzymatic protein hydrolysates for specialized food products. Scientific Works of NUFT. 2020;26(3):197–204. (in Ukrainian).
31. Singh N, Paul M, Mudgal S, Kaur A. Nutritional properties of proteins from different sources and their role in sports performance. In: Tiwari BK, Healy LE, editors. Future Proteins. Academic Press; 2023. p. 391–407. https://doi.org/10.1016/B978-0-323-91739-1.00018-0
32. Szedlak C, Robins A. Protein requirements for strength training. Strength Cond J. 2012 Oct;34(5):85–91. https://doi.org/10.1519/SSC.0b013e31826dc3c4
33. Kaur L, Mao B, Beniwal AS, Abhilasha, Kaur R, Chian FM, Singh J. Alternative proteins vs animal proteins: the influence of structure and processing on their gastro-small intestinal digestion. Trends Food Sci Technol. 2022;122:275–286. https://doi.org/10.1016/j.tifs.2022.02.021

34. Li W, Dong W, Tian C, Zhao Y, Li Y. Hydrolysis behavior evaluation of sports protein supplements with different composition and dosage forms: in vitro dynamic gastric digestion. LWT. 2025;215:117274. https://doi.org/10.1016/j.lwt.2024.117274
35. Avdieieva LYu, Dekusha HV, Turchyna TYa, Makarenko AA. The use of different drying methods in the technology of dry mushroom concentrates. Thermophysics and Thermal Power Engineering. 2023;45(3):37–48. https://doi.org/10.31472/ttpe.3.2023.5 (in Ukrainian).
36. Nasri M. Protein hydrolysates and biopeptides: production, biological activities and applications in foods and health benefits. Adv Food Nutr Res. 2017;81:109–159. https://doi.org/10.1016/bs.afnr.2016.10.003
37. Dullius A, Goettert MI, Volken de Souza CF. Whey protein hydrolysates as a source of bioactive peptides for functional foods – Biotechnical facilitation of industrial scale-up. J Funct Foods. 2018;42:58–74. https://doi.org/10.1016/j.jff.2017.12.063
38. Avdieieva L., Zhukotskyi E., Dekusha H. Influence of technological parameters on the degree of enzymatic hydrolysis of high-protein products. Ukrainian Food Journal, 2019, 8.(4), pp. 828–839 https://doi.org/10.24263/2304-974X-2019-8-4-13
39. Morgan PT, Breen L. The role of protein hydrolysates for exercise-induced skeletal muscle recovery and adaptation: a current perspective. Nutr Metab (Lond). 2021;18:44. https://doi.org/10.1186/s12986-021-00574-z
40. Duttagupta S, Roy NK, Dey G. Efficacy of amino acids in sports nutrition: review of clinical evidences. Food Res Int. 2024;187:114311. https://doi.org/10.1016/j.foodres.2024.114311
41. Marcon M, Zanella PB. The effect of branched-chain amino acids supplementation in physical exercise: a systematic review of human randomized controlled trials. Sci Sports. 2022;37(5-6):393-404. https://doi.org/10.1016/j.scispo.2021.05.006
42. AbuMoh'd MF, Matalqah L, Al-Abdulla Z. Effects of oral branched-chain amino acids (BCAAs) intake on muscular and central fatigue during an incremental exercise. J Hum Kinet. 2020;72:69-78. https://doi.org/10.2478/hukin-2019-0099
43. Smith-Ryan AE, Hirsch KR, Saylor HE, Gould LM, Blue MNM. Nutritional considerations and strategies to facilitate injury recovery and rehabilitation. J Athl Train. 2020;55(9):918-930 https://doi.org/10.4085/1062-6050-550-19
44. Papadopoulou SK. Rehabilitation nutrition for injury recovery of athletes: the role of macronutrient intake. Nutrients. 2020;12(8):2449. https://doi.org/10.3390/nu12082449
45. Quintero KJ, Resende ADS, Leite GSF, Junior AHL. An overview of nutritional strategies for recovery process in sports-related muscle injuries. Nutrire. 2018;43:27. https://doi.org/10.1186/s41110-018-0084-z
46. Matsui Y, Takayanagi S, Ohira T, Watanabe M, Murano H, Furuhata Y, Miyakawa S. Effect of a leucine-enriched essential amino acids mixture on muscle recovery. J Phys Ther Sci. 2019;31(1):95-101. https://doi.org/10.1589/jpts.31.95
47. Kato H, Suzuki H, Mimura M, et al Leucine-enriched essential amino acids attenuate muscle soreness and improve muscle protein synthesis after eccentric contractions in rats. Amino Acids. 2015;47:1193-1201. https://doi.org/10.1007/s00726-015-1946-9
48. Pasiakos SM, McClung HL, McClung JP, et al. Leucine-enriched essential amino acid supplementation during moderate steady state exercise enhances postexercise muscle protein synthesis. Am J Clin Nutr. 2011;94(3):809-818. https://doi.org/10.3945/ajcn.111.017061
49. Hespel P, Derave W. Ergogenic effects of creatine in sports and rehabilitation. Subcell Biochem. 2007;46:245-259.
50. Mienaltowski MJ, Birk DE. Structure, physiology, and biochemistry of collagens. Adv Exp Med Biol. 2014;802:5-29. https://doi.org/10.1007/978-94-007-7893-1_2
51. Smith K, Rennie MJ. New approaches and recent results concerning human-tissue collagen synthesis. Curr Opin Clin Nutr Metab Care. 2007;10(5):582-590. https://doi.org/10.1097/MCO.0b013e328285d858
52. Shaw G, Lee-Barthel A, Ross ML, Wang B, Baar K. Vitamin C-enriched gelatin supplementation before intermittent activity augments collagen synthesis. Am J Clin Nutr. 2017;105(1):136-143. https://doi.org/10.3945/ajcn.116.138594
53. Lis DM, Baar K. Effects of different vitamin C-enriched collagen derivatives on collagen synthesis. Int J Sport Nutr Exerc Metab. 2019;29(5):526-531. https://doi.org/10.1123/ijsnem.2018-0385
54. Turnagöl HH, Koşar ŞN, Güzel Y, Aktitiz S, Atakan MM. Nutritional considerations for injury prevention and recovery in combat sports. Nutrients. 2021;14(1):53. https://doi.org/10.3390/nu14010053
55. Moran D, Heled Y, Arbel Y, Israeli E, Finestone AS, Evans RK, Yanovich R. Dietary intake and stress fractures among elite male combat recruits. J Int Soc Sports Nutr. 2012;9(1):6. https://doi.org/10.1186/1550-2783-9-6
56. Sale C, Elliott-Sale KJ. Nutrition and athlete bone health. Sports Med. 2019;49:139–151. https://doi.org/10.1007/s40279-019-01161-2
57. Taghizadeh M, Farzin N, Taheri S, et al The effect of dietary supplements containing green tea, capsaicin and ginger extracts on weight loss and metabolic profiles in overweight women: a randomized double-blind placebo-controlled clinical trial. Ann Nutr Metab. 2017;70(4):277–285. https://doi.org/10.1159/000471889
58. Askarpour M, Hadi A, Miraghajani M, Symonds ME, Sheikhi A, Ghaedi E. Beneficial effects of L-carnitine supplementation for weight management in overweight and obese adults: an updated systematic review and dose-response meta-analysis of randomized controlled trials. Pharmacol Res. 2020;151:104554. https://doi.org/10.1016/j.phrs.2019.104554
59. Watanabe M, Risi R, Masi D, et al Current evidence to propose different food supplements for weight loss: a comprehensive review. Nutrients. 2020;12(9):2873. https://doi.org/10.3390/nu12092873
60. Dwyer JT, Allison DB, Coates PM. Dietary supplements in weight reduction. J Am Diet Assoc. 2005;105(5 Suppl 1):S80–S86. https://doi.org/10.1016/j.jada.2005.02.028
61. Jagim AR, Harty PS, Tinsley GM, Kerksick CM, Gonzalez AM, Kreider RB, et al. International society of sports nutrition position stand: energy drinks and energy shots. J Int Soc Sports Nutr. 2023;20(1). https://doi.org/10.1080/15502783.2023.2171314
62. Jagim AR, Harty PS, Barakat AR, Erickson JL, Carvalho V, Khurelbaatar C, Camic CL, Kerksick CM. Prevalence and amounts of common ingredients found in energy drinks and shots. Nutrients. 2022;14(2):314. https://doi.org/10.3390/nu14020314
63. Kloby Nielsen LL, Tandrup Lambert MN, Jeppesen PB. The effect of ingesting carbohydrate and proteins on athletic performance: a systematic review and meta-analysis of randomized controlled trials. Nutrients. 2020;12(5):1483. https://doi.org/10.3390/nu12051483
64. McNaughton LR, Gough L, Deb S, Bentley D, Sparks SA. Recent developments in the use of sodium bicarbonate as an ergogenic aid. Curr Sports Med Rep. 2016;15(4):233–244. https://doi.org/10.1249/JSR.0000000000000283
65. Arenas-Jal M, Suñé-Negre JM, Pérez-Lozano P, García-Montoya E. Trends in the food and sports nutrition industry: a review. Crit Rev Food Sci Nutr. 2020;60(14):2405–2421. https://doi.org/10.1080/10408398.2019.1643287
66. Outram S, Stewart B. Doping through supplement use: a review of the available empirical data. Int J Sport Nutr Exerc Metab. 2015;25(1):54–59. https://doi.org/10.1123/ijsnem.2013-0174
67. Fogelholm M, Burke L, Deakin V. Micronutrients: vitamins, minerals and antioxidants. In: Burke L, Deakin V, editors. Clinical Sports Nutrition. 5th ed. New York: McGraw Hill; 2015. p. 310–345.

68. Jordan SL, Albracht-Schulte K, Robert-McComb JJ. Micronutrient deficiency in athletes and inefficiency of supplementation: Is low energy availability a culprit? PharmaNutrition. 2020;14:100229. https://doi.org/10.1016/j.phanu.2020.100229
69. Ayotte D Jr, Corcoran MP. Individualized hydration plans improve performance outcomes for collegiate athletes engaging in in-season training. Journal of the International Society of Sports Nutrition. 2018;15(1):27. https://doi.org/10.1186/s12970-018-0230-2
70. Wolf ST, Stanhewicz AE, Clarke MM, Cheuvront SN, Kenefick RW, Kenney WL. Age-related differences in water and sodium handling after commercial hydration beverage ingestion. Journal of Applied Physiology (Bethesda, Md.: 1985). 2019;126(4):1042–1048. https://doi.org/10.1152/japplphysiol.01094.2018
71. Ayaz A, Zaman W, Radák Z, Gu Y. Harmony in Motion: Unraveling the Nexus of Sports, Plant-Based Nutrition, and Antioxidants for Peak Performance. Antioxidants. 2024;13(4):437. https://doi.org/10.3390/antiox13040437
72. Dixit V, Joseph Kamal S W, Chole B, Dayal P, Chaubey K K, Pal A K, Xavier J, Manjunath B T, Bachheti R K. Functional Foods: Exploring the Health Benefits of Bioactive Compounds from Plant and Animal Sources. J Food Qual. 2023;2023:5546753. https://doi.org/10.1155/2023/5546753
73. Deng G F, Shen C, Xu X R, et al Potential of fruit wastes as natural resources of bioactive compounds. Int J Mol Sci. 2012;13(7):8308–8323. https://doi.org/10.3390/ijms13078308
74. Deng G F, Lin X, Xu X R, Gao L L, Xie J F, Li H B. Antioxidant capacities and total phenolic contents of 56 vegetables. J Funct Foods. 2013;5(1):260–266. https://doi.org/10.1016/j.jff.2012.10.015
75. Naderi A, Rezaei S, Moussa A, Levers K, Earnest CP. Fruit for sport. Trends Food Sci Technol. 2018;74:85-98. https://doi.org/10.1016/j.tifs.2018.02.013.
76. Lamprecht M. Supplementation with mixed fruit and vegetable concentrates in relation to athlete's health and performance: scientific insight and practical relevance. Med Sport Sci. 2012;59:70–85. https://doi.org/10.1159/000341960
77. Jafari S, Jafari SM, Ebrahimi M, Kijpatanasilp I, Assatarakul K. A decade overview and prospect of spray drying encapsulation of bioactives from fruit products: Characterization, food application and in vitro gastrointestinal digestion. Food Hydrocoll. 2023;134:108068. https://doi.org/10.1016/j.foodhyd.2022.108068.
78. Liu B, Sun J, Han L, Yin Y, Meng X. Preparation of dihydroquercetin microcapsules with sodium starch octenyl succinate and maltodextrin as wall materials to improve stability, solubility and bioaccessibility. Food Chem. 2025;493(4):146072. https://doi.org/10.1016/j.foodchem.2025.146072.
79. McMahon N F, Leveritt M D, Pavey T G. The effect of dietary nitrate supplementation on endurance exercise performance in healthy adults: a systematic review and meta-analysis. Sports Med. 2017;47(4):735–756. https://doi.org/10.1007/s40279-016-0617-7
80. Williams M. Dietary supplements and sports performance: herbals. J Int Soc Sports Nutr. 2006;3(1):1–6. https://doi.org/10.1186/1550-2783-3-1-1
81. Knapik JJ, Steelman RA, Hoedebecke SS, Austin KG, Farina EK, Lieberman HR. Prevalence of dietary supplement use by athletes: systematic review and meta-analysis. Sports Med. 2016;46(1):103–123. https://doi.org/10.1007/s40279-015-0387-7
82. Maughan RJ, Burke LM, Dvorak J, et al. IOC consensus statement: dietary supplements and the high-performance athlete. Br J Sports Med. 2018;52(7):439–455. https://doi.org/10.1136/bjsports-2018-099027
83. McLellan TM, Caldwell JA, Lieberman HR. A review of caffeine's effects on cognitive, physical and occupational performance. Neurosci Biobehav Rev. 2016;71:294–312. https://doi.org/10.1016/j.neubiorev.2016.09.001
84. Pickering C, Grgic J. Caffeine and exercise: what next? Sports Med. 2019;49(7):1007–1030. https://doi.org/10.1007/s40279-019-01101-0
85. Garcia JF, Arribalzaga S, Díez R, Lopez C, Fernandez MN, Garcia JJ, Diez MJ, Seco-Calvo J, Sierra M, Sahagún AM. Herbs as an active ingredient in sport: availability and information on the Internet. Nutrients. 2022;14(13):2764. https://doi.org/10.3390/nu14132764
86. Sellami M, Slimeni O, Pokrywka A, Kuvačić G, Hayes LD, Milic M, Padulo J. Herbal medicine for sports: a review. Journal of the Int. Society of Sports Nutrition. 2018;15(1):14. https://doi.org/10.1186/s12970-018-0218-y
87. Bucci LR. Selected herbals and human exercise performance. The American Journal of Clinical Nutrition. 2000;72(2 Suppl):624S–636S. https://doi.org/10.1093/ajcn/72.2.624s
88. Gurney T, Bradley N, Izquierdo D, Ronca F. Cognitive effects of guarana supplementation with maximal intensity cycling. The British Journal of Nutrition. 2023;130(2):253–260. https://doi.org/10.1017/S0007114522002859
89. Pomportes L, Brisswalter J, Casini L, Hays A, Davranche K. Cognitive performance enhancement induced by caffeine, carbohydrate and guarana mouth rinsing during submaximal exercise. Nutrients. 2017;9(6):589. https://doi.org/10.3390/nu9060589
90. Nobari H, Saedmocheshi S, Chung LH, Suzuki K, Maynar-Mariño M, Pérez-Gómez J. An overview on how exercise with green tea consumption can prevent the production of reactive oxygen species and improve sports performance. International Journal of Environmental Research and Public Health. 2021;19(1):218. https://doi.org/10.3390/ijerph19010218
91. Peluso I, Serafini M. Antioxidants from black and green tea: from dietary modulation of oxidative stress to pharmacological mechanisms. British Journal of Pharmacology. 2017;174(11):1195–1208. https://doi.org/10.1111/bph.13649
92. Broeckel J, Estes L, Leonard M, Dickerson BL, Gonzalez DE, Purpura M, Jäger R, Sowinski RJ, Rasmussen CJ, Kreider RB. Effects of ginger supplementation on markers of inflammation and functional capacity in individuals with mild to moderate joint pain. Nutrients. 2025;17(14):2365. https://doi.org/10.3390/nu17142365
93. Wilson PB. Ginger (Zingiber officinale) as an analgesic and ergogenic aid in sport: a systematic review. J Strength Cond Res. 2015;29(10):2980–2995. https://doi.org/10.1519/JSC.0000000000001098
94. Hattori S, Omi N, Yang Z, Nakamura M, Ikemoto M. Effect of ginger extract ingestion on skeletal muscle glycogen contents and endurance exercise in male rats. Phys Act Nutr. 2021;25(2):15–19. https://doi.org/10.20463/pan.2021.0010
95. Giuriato G, Venturelli M, Matias A, Soares EMKVK, Gaetgens J, Frederick KA, Ives SJ. Capsaicin and its effect on exercise performance, fatigue and inflammation after exercise. Nutrients. 2022;14(2):232. https://doi.org/10.3390/nu14020232
96. Kawabata F, Inoue N, Yazawa S, Kawada T, Inoue K, Fushiki T. Effects of CH-19 sweet, a non-pungent cultivar of red pepper, in decreasing the body weight and suppressing body fat accumulation by sympathetic nerve activation in humans. Biosci Biotechnol Biochem. 2006;70(12):2824–2835. https://doi.org/10.1271/bbb.60206
97. Hirsch KR, Smith-Ryan AE, Roelofs EJ, Trexler ET, Mock MG. Cordyceps militaris improves tolerance to high-intensity exercise after acute and chronic supplementation. J Diet Suppl. 2017;14(1):42–53. https://doi.org/10.1080/19390211.2016.1203386

98. Vidal VAS, Jensen I-J, Sandbakk Ø, Haugnes P, Austeen MW, Gjeldnes R, et al. Military rations: Nutritional, sensorial and technological quality and their effects on military physical exercise in extreme environments. Nutrition Research Reviews. 2025;38(1):324–37. https://doi.org/10.1017/S0954422424000246
99. Masliychuk OB, Simakhina GO, Naumenko NV. Scientific principles for the development of high-protein products in the diet of military personnel. Tavriyskyi Scientific Bulletin. Series: Technical Sciences. 2024;(6):120–131 https://doi.org/10.32782/tnv-tech.2023.6.14 (in Ukrainian).
100. Knapik JJ, Trone DW, Steelman RA, Farina EK, Lieberman HR. Prevalence, factors associated with use, and adverse effects of sport-related nutritional supplements (sport drinks, sport bars, sport gels): the US military dietary supplement use study. J Int Soc Sports Nutr. 2021;18(1):59. https://doi.org/10.1186/s12970-021-00457-x
101. Polishchuk HE, Simakhina HO, Semko TV, Ustymenko IM. Pastelike milk-containing products for nutrition of military personnel. Agrarian Science and Food Technologies. 2015;(1):187–199. (in Ukrainian).
102. Goyko I, Stetsenko N. Analysis and trends in the organisation of military catering in different countries of the world. Anim Husb Prod Prod Process. 2024;1:127–135. https://doi.org/10.33245/2310-9289-2024-186-1-127-135 (in Ukrainian).
103. Murphy NE, Carrigan CT, Philip Karl J, Pasiakos SM, Margolis LM. Threshold of energy deficit and lower-body performance declines in military personnel: a meta-regression. Sports Med (Auckland, N.Z.) 2018 Sep;48(9):2169–2178. https://doi.org/10.1007/s40279-018-0945-x
104. Hargreaves M, Spriet LL. Skeletal muscle energy metabolism during exercise. Nature Metab. 2020;2(9):817–828. https://doi.org/10.1038/s42255-020-0251-4
105. Kimura M, Moriyasu A, Makizako H. Positive association between high protein food intake frequency and physical performance and higher-level functional capacity in daily life. Nutrients. 2021;14(1):72. https://doi.org/10.3390/nu14010072
106. Buga A, Crabtree CD, Stoner JT, Decker DD, Robinson BT, Kackley ML, et al. Metabolic and ruck performance effects of a novel, light-weight, energy-dense ketogenic bar. Experimental Physiology. 2023;108(5):715–727. https://doi.org/10.1113/EP091029
107. Ahmed M, Mandic I, Lou W, Goodman L, Jacobs I, L'Abbé MR. Comparison of dietary intakes of Canadian Armed Forces personnel consuming field rations in acute hot, cold, and temperate conditions with standardized infantry activities. Military Medical Research. 2019;6(1):26. https://doi.org/10.1186/s40779-019-0216-7

РОЗВИТОК ІНДУСТРІЇ ПРОДУКТІВ ХАРЧУВАННЯ ДЛЯ ЛЮДЕЙ З ПІДВИЩЕНИМ ФІЗИЧНИМ НАВАНТАЖЕННЯМ

Л.Ю. Авдєєва, доктор технічних наук, старший науковий співробітник, E-mail: avdeeva22@ukr.net
А.А. Макаренко, кандидат технічних наук, старший дослідник E-mail: tbds_ittf@ukr.net
Інститут технічної теплофізики НАН України
вул. Марії Капніст 2а, м. Київ, Україна, 03057

Анотація В усьому світі індустрія харчування для людей з підвищеним фізичним навантаженням переживає бурхливого розвитку. Для України найбільш гостро цей фактор стосується харчування військових і спортсменів, які знаходяться під постійним впливом фізичних та психоемоційних навантажень. Проблеми харчування для людей з підвищеним фізичним навантаженням, в т.ч. спортсменів і військових є багатофакторними, пов'язаними з особливостями основного раціону харчування, характером фізичного навантаження і відповідності енергетичних витрат та багато ін. Аналізуючи багаточисельні дослідження закордонних і вітчизняних вчених можна зробити висновок, що ефективним способом задоволення підвищених потреб організму спортсменів та військових є додаткове споживання в раціоні харчових добавок різного складу і спрямування. Збільшення попиту стимулює подальший розвиток виробництва і створення нових інноваційних технологій продуктів і добавок різного складу і призначення і робить цей напрямок актуальним, який постійно розвивається. Метою досліджень було проаналізувати стан і тенденції розвитку індустрії продуктів харчування для людей з підвищеним фізичним навантаженням, в т.ч. спортсменів і військових. Поточна класифікація спортивного харчування різниться для різних країн. Загалом, цей ринок є дуже різноманітним і охоплює виробництво протеїнових порошків, спортивних напоїв, енергетичних батончиків, білково-вуглеводних продуктів, різноманітних функціональних і енергетичних добавок та багато ін. Протеїнові порошки і їх похідні останніми роками зберігають найвищий попит і займають найбільший сегмент ринку. Значною популярністю користуються вуглеводні і білково-вуглеводні комплекси. Значну частку продукції займають добавки для відновлення після травм м'язів, суглобів та кісток. Інновації стосуються розроблення нових спеціалізованих формул для задоволення швидко зростаючого спектру дієтичних потреб і оздоровчих цілей, пошуку ефективних систем доставки біологічно активних речовин, покращенню засвоювання і збільшенню біодоступності нутрієнтів.

Ключові слова: оздоровче харчування, спортивне харчування, військове харчування, протеїни, гідролізати білків, біологічно активні речовини, білково-овочеві концентрати

Received 27.01.2026 **Reviewed 16.02.2026**
Revised 04.02.2026 **Approved 03.03.2026**