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# Development of Dry Mixtures for Protein-Carbohydrate Drinks Used for Sports Nutrition

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## **Abstract**

This work is aimed at developing mixtures of protein-carbohydrate drinks used in sports nutrition. Specialized protein-carbohydrate products are the powdered food mixtures with a high content of proteins and carbohydrates required for maintaining and increasing the muscle mass, restoring the glycogen levels in the muscles and the liver, and for correcting the diet of an athlete. At the first stage, theoretical work was carried out aimed at the generalization and analysis of scientific literature. Based on the literature review, biomedical and technological requirements for specialized protein-carbohydrate products for the nutrition of athletes were systematized. In accordance with the requirements, the components (Fonterra WPC 80 protein, skim milk, fructose, cocoa powder, egg albumin, maltodextrin, thickener, natural dyes, flavoring substances) were selected and justified, and the formulation of the developed products was calculated. Further research was aimed at studying the influence of product components and technological factors on the physicochemical properties of carbohydrates and proteins in the model "protein-polysaccharide-water" system. Calculation of the biological value of protein preparations was conducted, as well as the experimental studies of the dry mixing technology aimed at selecting the sequence of the introduction of components for the production of dry multi-component specialized products. Based on theoretical studies and generalizations, technological requirements and modes have been specified, and the technology of dry mixtures of protein-carbohydrate drinks for sports nutrition has been developed. Product optimization, its physicochemical, and organoleptic studies have allowed developing draft technical documentation for dry mixtures of protein-carbohydrate drinks for sports nutrition.

Keywords: Protein-carbohydrate mixtures, maltodextrin, egg albumin, whey protein, drink concentrates

# 1 Introduction

Currently, making specialized products for sports nutrition is an urgent task for the modern food industry [1-5]. The popularity of this group of food products in Europe, the USA, and Russia is shown by the statistics of the qualitative and quantitative changes in the food market. Highly skilled athletes often experience deficiency of the key macro- and microcomponents, which significantly impairs the athletic performance and the overall health, therefore, one of the solutions to this problem is including specialized protein-carbohydrate products with high biological value into the diet of athletes so that they can quickly restore the glycogen reserves in the muscles and the liver, respectively, and prevent the loss of muscle protein during intensive workouts.

The range of specialized protein-carbohydrate products for sports nutrition is widely presented in the market by domestic and, for the most part, foreign manufacturers. In recent years rapid advances have been seen in the development and use of specialized protein-carbohydrate food products for athletes. However, industrial production in our country is very limited [1, 6-10]. Currently, the best sources of high-quality protein are milk proteins. Milk proteins consist of casein (85%) and whey proteins (15%). They are digested and absorbed evenly: first, low-

molecular whey proteins, followed by high-molecular casein. This property of milk protein is especially important when it is used for dietary purposes and muscle recovery after workouts of various intensities [11, 12]. To better provide amino acids to the organism before, during, and after exercises, specialized proteincarbohydrate products for athletes should contain concentrates, isolates, and hydrolysates of whey protein. To further stimulate the synthesis of muscle fibers in the organism, various micronutrients, especially vitamins, minerals, etc. are usually added to specialized protein-carbohydrate food products. As a rule, they include well-chosen combinations of vitamins, mineral premixes, and other nutrients in certain ratios, rather than individual vitamins and minerals. This is because many chemical processes in the organism are catalyzed simultaneously by several interacting vitamins, macro- and microelements [13-17]. The carbohydrate complex in specialized protein-carbohydrate food mixtures for the nutrition of athletes is represented by several types of carbohydrates - maltodextrin, glucose polymers, and fructose [3, 14, 18-25].

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### 2 Literature review

Specialized protein-carbohydrate products are powdered food mixtures with a high content of proteins and carbohydrates required for maintaining and increasing the muscle mass, restoring the glycogen levels in the muscles and the liver, and for correcting the diet of an athlete [26-28]. Most often, specialized protein-carbohydrate-enriched food products for athletes are available in the form of powders and are used as drinks. The content of glycogen in the muscles during intensive exercises may be reduced in less than an hour, but restoring it to the previous level using everyday diet takes several days [29]. The restoration of the glycogen levels and enhancing the synthesis of new muscle fibers are supported by additional intake of carbohydrates and proteins into the organism of an athlete, which is often achieved by including specialized protein-carbohydrate food mixtures with high biological value into the diet of the athletes [1, 20, 30].

In developing this type of product, environmentally friendly raw materials of animal and plant origin must be used along with biologically active supplements that improve their functional and consumer qualities [31-36]. The technology of manufacturing specialized protein-carbohydrate products for sports nutrition should envisage highly efficient manufacturing processes that preserve the nutritional value of raw materials and ensure obtaining a product with desired functional properties. In this regard, the most promising is the use of dry mixing technology [37, 38]. Optimization of the processes for the production of specialized dry products using the method of components dry mixing has several specific features since the issue discussed is biological systems and certain components mixing conditions, which may have a significant effect on their quality. Therefore, successful optimization of the mixing process to develop a

product technology requires additional study of this aspect.

# 3 Materials and methods

## 3.1 General description

During the experimental part, the objects of the study were the components of the developed protein-carbohydrate product, and the Whey protein finished product. Considering their high biological value, whey proteins and egg albumin were used in the product as a source of protein: concentrate of dried egg albumin of the OVOPROT brand (production of OVOPROT INTERNATIONAL, Argentina), the dry concentrate of whey protein of the Fonterra 80 brand (production of Fonterra Ltd, New Zealand), the dry concentrate of whey protein of the Lactomin 80 brand (production of Deutschland GmbH, Germany). The physicochemical properties of the components are presented in Tables 1-3.

Whey proteins and egg albumin have the highest degradation and digestibility rates among whole proteins. The amino acid composition of the considered proteins is the closest to the amino acid composition of human muscle tissue, and in terms of the content of essential amino acids and branched-chain amino acids (BCAAs): valine, leucine and isoleucine, they surpass all other proteins of animal and vegetable origin. BCAAs are the main initiating factors in eliminating energy deficits during their metabolism and create the conditions for the favorable occurrence of energy-dependent synthetic processes, including glycogen formation. Skim milk powder in its composition contains amino acids essential for the body. B vitamins, vitamins A and D, as well as minerals: phosphorus, potassium, calcium, sulfur, magnesium, chlorine, and others. Proteins of milk powder are slowly absorbed, and for a long time, serve as a source of replenishment of the level of amino acids in the blood.

Table 1: Physicochemical properties of protein-containing components

| Name of components              | Protein       | Fat content,% | Mass fraction of | Ash,% max. | Solution pH |
|---------------------------------|---------------|---------------|------------------|------------|-------------|
|                                 | content,% not | min           | moisture,% max.  |            |             |
|                                 | less          |               |                  |            |             |
| Concentrate of egg albumin of   | 85.0          | 0.02          | 6.0              | 4.5        | 5.0-7.5     |
| the OVOPROT brand               |               |               |                  |            |             |
| Concentrate of whey protein of  | 80.0          | 5.0           | 4.5              | 3.0        | 6.1-6.5     |
| the Fonterra 80 brand           |               |               |                  |            |             |
| Concentrate of whey protein of  | 80.0          | 3.0           | 5.5              | 4.0        | 6.5-7.2     |
| the Lactomin 80 brand           |               |               |                  |            |             |
| Whey protein concentrate of the | 80.0          | 8.0           | 5.5              | 3.5        | 6.1-6.5     |
| Milkiland 80 brand              |               |               |                  |            |             |

Table 2: Physicochemical properties of the components

|                           | Table 2:                      | Physicochemical prope | rues of the componer        | its                              |            |
|---------------------------|-------------------------------|-----------------------|-----------------------------|----------------------------------|------------|
| Name of components        | Protein content,%<br>not less | Fat content,% max     | Carbohydrate content,% max. | Mass fraction of moisture,% max. | Ash,% max. |
| Skim milk powder          | 49.9                          | 1.0                   | 41.1                        | 5.5                              | 8.0        |
| Frima dry vegetable cream | 2.0                           | 26.0                  | 62.0                        | 4.5                              | 3.5        |

Table 3: Physicochemical properties of berry powders

| Table 5: Physicochemical properties of berry powders |                               |                    |                             |                      |                                  |
|--|-------------------------------|--------------------|-----------------------------|----------------------|----------------------------------|
| Name of components                                   | Protein content,%<br>not less | Fat content,% min. | Carbohydrate content,% max. | Sugar content,% max. | Mass fraction of moisture,% max. |
| Dried Raspberry Powder                               | 8.2                           | 4.0                | 55.1                        | 54.0                 | 4.0-5.0                          |
| Dried Strawberry Powder                              | 8.2                           | 4.0                | 55.1                        | 54.0                 | 4.0-5.0                          |

The use of a mixture of maltodextrin and fructose (a mixture of carbohydrates with high and low glycemic index) leads to an increase in the rate of oxidation of exogenous carbohydrates compared to using each carbohydrate separately [11, 13, 30, 39]. As sources of carbohydrates, GLUSIDEX 19 maltodextrin (production of ROQUETTE, France), DE 18-20, and CornSweet fructose (ADM, USA) in a 1:3 ratio were used. Dry skim milk (production of Lepel Dairy Canning Plant, JSC Vitebsk Meat Plant, Belarus) and dry vegetable cream Frima (production of DONGSUH, Korea) were selected as an additional source of protein. Xanthan gum (production of Deosen Biochemical Ltd, China), with the basic substance content of 80%, was used as a stabilizer for emulsions and suspensions, and also as a thickener increasing the viscosity of beverages. When creating the flavor and aroma range of the product being developed, natural berry powders (strawberry and raspberry) were used that provided high organoleptic properties of the finished product: dried raspberry powder 0 - 2 mm (production of YANTAI XUEHAI FOODSTUFFS CO., LTD China), dried strawberry powder 3 - 6 mm (production of YANTAI XUEHAI FOODSTUFFS CO., LTD China). Luxomix beta-carotene food dye (production of BARGUS TRADE, Russia); Luxomix carmine food dye (production of BARGUS TRADE, Russia); and Vanilla, Chocolate, Strawberry, Raspberry food flavors (production of BARGUS TRADE Russia) were used as dye and flavoring agents. Food flavors met the requirements of TR TS 029/2012 "Safety requirements for food additives, flavors, and technological aids." Based on the experimental studies of the functional properties of the product components, testing the sequence of introducing components for mixing and following the technological requirements for the product, the composition, and flowchart for the production of the dry protein-carbohydrate product named "Whey protein" for athletes nutrition was developed. The technological process of the developed product production was carried out according to the technological scheme. In conformity with the technological scheme, the production of a product in the form of dry powder included the following stages: acceptance and storage of raw materials; preparation of raw materials; dry mixing of components in the mixer; product packaging; packaging and labeling of the finished product.

The production of Whey protein was carried out by dry mixing of the components. Since the final product is a multi-component mixture, to obtain a high-quality product, it was advisable to carry out the production by sequential mixing according to a three-stage scheme. At the first stage, microcomponents were mixed: skim milk, xanthan gum, dyes, food flavors. Mixed components were sent to a hopper for temporary storage. At the second stage, the mixture prepared at the first stage was mixed with maltodextrin, whey protein preparation, egg white preparation, vegetable cream, and fructose.

In the third stage, the mixture prepared at the second stage was mixed with sublimated berries. Mixing time was 50-60 minutes when rotating in a mixer at 50 rpm. After mixing, the finished product was put into a weighing batcher and then the filling machine. Products were packaged in consumer packaging: a jar or bag made of polymeric materials with a measuring spoon or in sachets intended for single use. In choosing the components and in developing the formulations of the mixtures for protein-carbohydrate drinks, the balance of essential amino acids relative to the chosen reference protein of FAO/WHO was taken into consideration [40]. With this aim in mind, the amino acid balance

was optimized. Specifically, the content of essential amino acids and their total balance in the studied protein concentrates were quantified. Not less important criteria for choosing protein concentrates used for creating protein-containing mixtures, in addition to their biological value, are their physicochemical characteristics. To determine the particle size distribution, the sieve analysis was used, based on the mechanical separation of the particles into size classes on sieves with holes of various sizes. The material that remained on the sieve after sieving is called BALANCE, and the material that has passed through the sieve is called THROUGHS.

In the work, the method of dispersion assessment in concentrates was used (GOST 1513.3-77). A sample taken from a pooled sample, weighing 40 g with the accuracy of not more than 0.1 g, was placed in a beaker, then 200 cm<sup>3</sup> of water heated to a temperature of  $(60 \pm 2)^{\circ}$ C was added, and the mixture was mixed thoroughly until a fine suspension was obtained and set at rest. The higher the dispersion of the suspension particles was, and the longer they were kept in suspension, the higher the quality of the drink was. The suspension was considered sufficiently dispersed if, in two minutes after mixing, noticeable sludge did not form. The height of the sludge level was determined using the coordinate paper. The solubility index was determined by the method of determining the dry milk products' solubility index according to GOST 30305.4-95. The essence of the method consists in determining the amount of undissolved sediment in the sample of the analyzed preparation. To determine the dispersibility, the method of determining the dissolution rate was used, in which mixing continued until all lumps of the dry concentrate were completely dispersed; and the dispersibility was equal to the mixing duration in seconds until all lumps were dissolved [28]. The wettability of the dry concentrate was determined by the method of Moore. Dry concentrate in the amount of 1.7 g was poured into a special funnel closed from below with a glass plate. Under the funnel, there was a beaker filled with 25 ml of distilled water with a temperature of  $(20 \pm 2)$ °C Then the plate was removed, the dry concentrate was poured into water, and the time of its complete immersion was recorded. Wettability was assessed by the time required to completely wet the dry concentrate. The results of the studies were processed in Microsoft Office Excel 2013. Studies were carried out in three- to five-fold repetition. The research results were processed using the methods of statistical analysis with the determination of the arithmetic mean value and mean square error.

## 4 Result analysis

The most important factors contributing to the enhancement of muscle protein synthesis required for ensuring high training level of the muscle system and its adaptation to power loads include the high biological value of food protein, which reflects the balance of essential amino acids with respect to the selected FAO/ WHO reference protein [40]. To this end, an amino acid balance optimization was carried out, namely, quantitative assessment of the correspondence of the content of essential amino acids and their total balance in the studied protein concentrates. The process of optimization involved such criteria as amino acid score, the ratio of the amino acid composition utility (U), and the coefficient of comparable redundancy of the essential amino acid content ( $\sigma_c$ ).

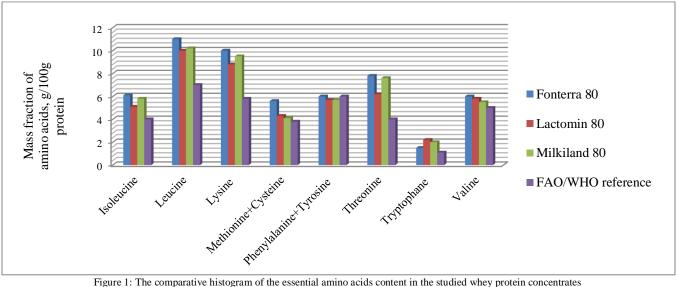


Figure 1: The comparative histogram of the essential amino acids content in the studied whey protein concentrates

To characterize the rationality of using amino acids, proteins were qualitatively assessed by the coefficient of amino acid composition utility (U) and indicator of comparable redundancy  $(\sigma_c)$ . The content of essential amino acids in the studied protein concentrates is shown in Figure 1. Analysis of the histogram of the amino acid composition shows that the most balanced relative to the reference FAO/WHO protein is dry whey protein concentrate of the Fonterra 80 brand. The indicators that characterize its amino acid balance ( $C_{min}$ , U,  $\sigma_c$ ) fully confirm the high biological value of protein. The indicators of the amino acid balance of the whey proteins are shown in Table 4.

Table 4: The indicators of the amino acid balance of dry whey

|   | proteins        |                |             |  |  |  |
|---|-----------------|----------------|-------------|--|--|--|
| Indicator   | Milkiland<br>80 | Lactomin<br>80 | Fonterra 80 |  |  |  |
| The minimum score C <sub>min</sub> , share units        | 0.83            | 0.85           | 1.00        |  |  |  |
| The coefficient of utility U, share units               | 0.61            | 0.63           | 0.67        |  |  |  |
| The coefficient of comparable redundancy $\sigma_c$ , g | 22.92           | 21.53          | 18.25       |  |  |  |

The concentrates of dry whey proteins (Lactomin 80 and Milkiland 80) contain limiting amino acids — phenylalanine and tyrosine, which decrease the biological value of these proteins and reduce the possibility of their utilization by the organism.

The factors that determine the solubility of dry protein concentrate include the physicochemical properties of particles of the product (dispersion, shape, and structure). Since the main components of the developed product are maltodextrin, whey proteins, and egg albumin, the granulometric composition of these components was studied. The particle size distribution and

the size depend on the process of obtaining the components and influence bulk density, flowability, and quick dissolution of the finished product. The results of analyzing the distribution of the actual particles in the components of maltodextrin and proteins are evidence of their different granulometric composition. It should be noted that particles of the Fonterra 80 brand whey protein dry concentrate and the OVOPROT brand dried egg concentrate of albumin represent rather large particles. At the same time, most particles in the concentrate of the Milkiland 80 brand dry whey protein are also linked into agglomerates; however, the average size of individual particles in the agglomerates in the Milkiland 80 brand whey protein dry concentrate is less than the size of the particles in the Fonterra 80 brand whey protein dry concentrate. Given the results of analyzing the actual distribution of particles and functional and technological properties (balanced carbohydrate composition and solubility), the most rational source of carbohydrates was determined to be the GLUSIDEX 19 maltodextrin.

The high bulk density of the protein or polysaccharides concentrate may indicate the presence of a sufficiently large number of single particles and minor amounts of agglomerates, which, in turn, affects the product dissolution rate. The results of analyzing the actual particle distribution in the studied components of proteins and polysaccharides are shown in Table 5. It should be noted that the granulometric composition, the shape and the size of particles, the degree of compaction, and their mutual arrangement determine important indicators of dry protein products such as the wettability and the dissolution rate. The change in the rate of protein solubility is shown in Figure 2.

The obtained graphic dependencies show that the maximum dissolution rate of all studied components is observed upon increasing the share of maltodextrin in the composition, but given the functional orientation of the developed product, the best is the protein to carbohydrates ratio of 40:60. This combination of the components provides quick dissolution of the product without affecting its functionality.

|  |   | 1 1 1                                 |
|--|---|---------------------------------------|
| Table 5: The results of analyzing the actual | narficles distribution in the studied cor | nnonents of profeins and malfodextrin |
| rable 5. The results of analyzing the actual | particles distribution in the studied con | inpolicints of proteins and manoackum |

|                             | Bulk density indic          | Bulk density indicators, kg/m |                | Mass fraction of particles (in %) of the total weight with their size, $\mu m$ |                |               |  |
|-----------------------------|-----------------------------|-------------------------------|----------------|--|----------------|---------------|--|
| Component names             | The volumetric bulk density | Bulk density                  | < 5            | 5 – 10   | 10 – 20        | > 20          |  |
| Fonterra 80                 | $238.4 \pm 1.2$             | $367.8 \pm 1.1$               | $15.5\pm2.1$   | $26.2 \pm 1.8$   | $47.1 \pm 2.3$ | $6.2 \pm 1.7$ |  |
| Lactomin 80                 | $313.2 \pm 0.9$             | $455.4 \pm 1.4$               | $57.1 \pm 2.7$ | $25.9 \pm 2.0$   | $12.7\pm2.7$   | $4.3 \pm 2.4$ |  |
| Milkiland 80                | $268.5 \pm 1.4$             | $282.3 \pm 1.3$               | $30.2 \pm 3.1$ | $27.7 \pm 2.4$   | $34.5 \pm 1.8$ | $7.6 \pm 2.1$ |  |
| OVOPROT egg<br>albumin      | $266 \pm 1$                 | $390 \pm 1.3$                 | $20.7 \pm 1.5$ | $30.3 \pm 2.4$   | $43.5 \pm 1.1$ | $5.5 \pm 2.0$ |  |
| GLUSIDEX 19<br>Maltodextrin | $335\pm1.5$                 | $359 \pm 1.2$                 | $16.5 \pm 2.1$ | $30.2\pm1.8$   | $50.1 \pm 2.3$ | $7.2 \pm 1.7$ |  |

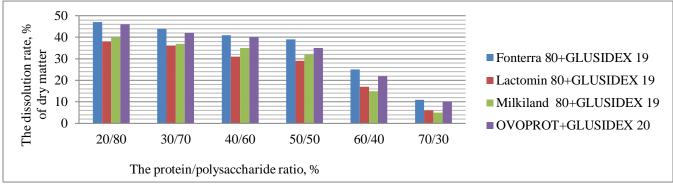


Figure 2: Change in the speed of proteins solubility depending on their ratio to polysaccharides (Maltodextrin GLUSIDEX 19)

The highest dissolution rate was observed in the Fonterra 80 dry whey protein concentrate and the OVOPROT dried egg albumin concentrate. This can likely explain the quantitative ratio between large and small particles and the presence of agglomerates in the composition of these components. The dissolution rate and the wettability are significantly affected by the temperature of the water in which the product is restored. Figures 3 and 4 show the curves that demonstrate the dynamic changes of wettability and the dissolution rate of the studied components of whey proteins, depending on the water temperature. The obtained graphical dependencies show that the minimum wetting time and the maximum dissolution rate of all studied components are observed in the temperature range between 40 and 50 °C. With the water temperature over 50 °C, the process of wetting and dissolution deteriorates due to the

formation of a heavily soluble film on the surface of the product. At the same time, among the studied protein concentrates, the best values of the studied parameters in the entire temperature range were noted in the Fonterra 80 dry whey protein concentrate. This is primarily due to the ratio of fine and coarse particles and the presence of agglomerates in the concentrate. Thus, analyzing the data obtained in studying the physicochemical characteristics and the biological value of the studied protein concentrates, a conclusion can be made that the use of dry concentrate of the Fonterra 80 whey protein will ensure obtaining a product with the desired properties following the technological requirements. According to the results obtained and based on the chemical composition of the ingredients, the formulation of the protein-carbohydrate product named Whey protein was calculated, which is presented in Table 6.

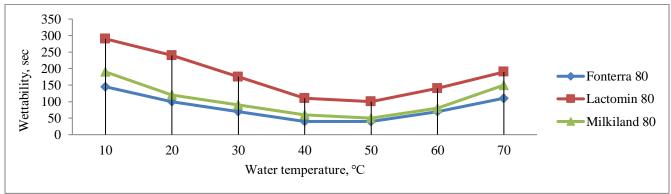


Figure 3: The effect of water temperature on the wettability of the studied concentrates of dry whey proteins

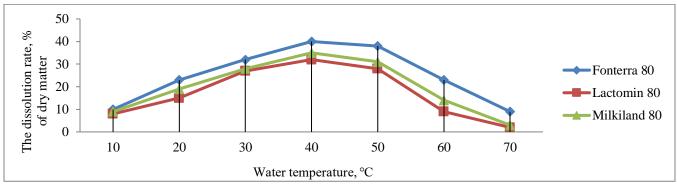


Figure 4: The effect of water temperature on the dissolution rate of the studied concentrates of dry whey proteins

Table 6: Estimated formulation of dry mixtures of protein-carbohydrate drinks named Whey protein

| D                            | Mass fraction of components,% |         |            |           |  |  |
|------------------------------|-------------------------------|---------|------------|-----------|--|--|
| Raw material name            | Chocolate                     | Vanilla | Strawberry | Raspberry |  |  |
| Fonterra WPC 80 protein      | 30.0                          | 30.0    | 30.0       | 30.0      |  |  |
| Egg albumin                  | 11.0                          | -       | -          | -         |  |  |
| Maltodextrin                 | 5.0                           | 9.0     | 9.0        | 9.0       |  |  |
| Skim milk                    | 20.0                          | 20.0    | 20.0       | 20.0      |  |  |
| Fructose                     | 15.0                          | 18.0    | 18.0       | 18.0      |  |  |
| Vegetable cream              | 6.6                           | 11.4    | 10.0       | 10.0      |  |  |
| Xanthan gum                  | 0.2                           | 0.2     | 0.2        | 0.2       |  |  |
| Cocoa powder                 | 12.0                          | -       | -          | -         |  |  |
| Carmine                      | -                             | -       | 0.2        | 0.2       |  |  |
| Carotene                     | -                             | 0.2     | -          | -         |  |  |
| Chocolate food flavour       | 0.2                           | -       | -          | -         |  |  |
| Vanilla food flavour         | -                             | 0.2     | -          | -         |  |  |
| Strawberry food flavour      | -                             | -       | 0.2        | -         |  |  |
| Raspberry food flavour       | -                             | -       | -          | 0.2       |  |  |
| Strawberry Sublimated Powder | -                             | -       | 1.4        | -         |  |  |
| Raspberry Sublimated Powder  | -                             | -       | -          | 1.4       |  |  |

Following the developed formulation and production technology, samples of the specialized protein-carbohydrate product Whey protein have been developed. The nutritional and energy value of the developed product is shown in Table 7. The physicochemical and organoleptic characteristics of the finished product have been studied. The organoleptic characteristics of dry protein-carbohydrate products and ready drinks (cocktails) are

shown in Tables 8 and 9. The samples of dry protein-carbohydrate concentrate and ready drinks have high organoleptic value. The main physicochemical characteristics of the product are shown in Table 10. The product is an easily soluble powder with the maximum duration of dissolution (without a stirrer) of 230-250 sec.

Table 7: Nutritional and energy value of the dry protein and carbohydrate product for athletes, per 100 g of the product

| Indicator name                              | Indicator value |
|---|-----------------|
| Calorific value, kcal                       | 401.5           |
| Mass fraction of moisture, %, not more than | 5.0             |
| Mass fraction of carbohydrates, g,          | 59.8            |
| Mass fraction of protein, g,                | 33.18           |
| Mass fraction of fat, g                     | 3.23            |

Table 8: Organoleptic characteristics of dry protein-carbohydrate products

| Name                                | Dry protein concentrates characteristic      |   |                            |  |  |
|-------------------------------------|--|---|----------------------------|--|--|
| Name —                              | Appearance                                   | Taste and smell   | Color                      |  |  |
| Whey protein with chocolate flavor  | Powdered. Easily crumbling lumps are allowed | The smell of chocolate, the taste is sweet with a hint of chocolate, without foreign tastes and odors       | brown,<br>homogeneous      |  |  |
| Whey protein with vanilla flavor    | Powdered. Easily crumbling lumps are allowed | The smell of vanilla, the taste is sweet<br>with a hint of vanilla, without foreign<br>tastes and odors     | beige,<br>homogeneous      |  |  |
| Whey protein with strawberry flavor | Powdered. Easily crumbling lumps are allowed | The smell of strawberries, the taste is<br>sweet with strawberry flavor, without<br>foreign tastes and odor | light pink,<br>homogeneous |  |  |
| Whey protein with raspberry flavor  | Powdered. Easily crumbling lumps are allowed | The smell of raspberry, the taste is sweet with raspberry flavor, without foreign tastes and odor           | light pink,<br>homogeneous |  |  |

Table 9: The organoleptic indicators of ready protein-carbohydrate drinks

| Nome                                | The characteristic of ready protein concentrates                          |  |                             |  |  |
|-------------------------------------|---|--|-----------------------------|--|--|
| Name -                              | Appearance  | Taste and smell  | Color                       |  |  |
| Whey protein with chocolate flavor  | Turbid liquid according to the recipe, without foreign inclusions.        | The taste is distinct, sweet, or sour-sweet with<br>the aroma of chocolate, according to the<br>recipe, without foreign tastes and odors.    | Brown, homogeneous          |  |  |
| Whey protein with vanilla flavor    | Turbid liquid according to the recipe, without foreign inclusions.        | The taste is distinct, sweet, or sour-sweet with<br>the aroma of vanilla, according to the recipe,<br>without foreign tastes and odors.      | Pale yellow,<br>homogeneous |  |  |
| Whey protein with strawberry flavor | Turbid liquid according to the recipe, with the inclusion of strawberries | The taste is distinct, sweet, or sour-sweet with<br>the aroma of strawberries, according to the<br>recipe. Without foreign tastes and odors. | Light pink, homogeneous     |  |  |
| Whey protein with raspberry flavor  | Turbid liquid according to the recipe, with the inclusion of raspberries  | The taste is distinct, sweet, or sour-sweet with<br>the aroma of raspberries, according to the<br>recipe. Without foreign tastes and odors.  | Light pink, homogeneous     |  |  |

Table 10: The main physicochemical characteristics of the developed product

| Indicator  | Analysis result |
|--|-----------------|
| Mass fraction of moisture, %                         | $5.32 \pm 0.2$  |
| Mass fraction of protein, %                          | $33.18 \pm 0.1$ |
| Mass fraction of fat, %                              | $3.23 \pm 0.19$ |
| Mass fraction of ash, %                              | $4.82 \pm 0.13$ |
| Mass fraction of carbohydrates, %                    | $59.8 \pm 0.13$ |
| Solubility index, cm <sup>3</sup> of the wet residue | $0.5 \pm 0.08$  |

## **5 Conclusion**

The nutrition problem is essential for athletes. The special physiological conditions that power and speed-power athlete experiences, lead to the increasing demands for nutrients, in particular, carbohydrates with different chain lengths, easily digestible proteins and basic micronutrients. However, daily nutrition does not ensure the intake of a sufficient amount of proteins and carbohydrates, and also does not guarantee their necessary ratio. One of the ways to solve this problem is the inclusion in the diet of athletes of specialized protein-carbohydrate products with the high biological value being able to quickly restore glycogen stores in the muscles and liver and prevent muscle protein loss during intense training. In recent years, in the field of development and application of specialized

protein-carbohydrate food products for athletes, rapid progress has been outlined; however, industrial production in Russia is very limited, and the technology itself requires objective scientific justification of the principles of their creation. In connection with the foregoing, the development and practical implementation of the technology of dry mixtures of protein-carbohydrate drinks for sports nutrition is relevant.

The composition of dry mixtures of protein-carbohydrate drinks is substantiated based on indicators of nutritional and biological value, as well as the functional orientation of the ingredients. The dissolution rate and viscosity of Whey and egg proteins were determined depending on the polysaccharide content in the model "protein-polysaccharide-water" system. The efficient ratio of 1:2 of the protein to the carbohydrate component

was determined, at which the reduced product in a given ratio provided its functional properties. Changes in the basic physicochemical parameters of the finished product, based on a change in the particle size distribution and bulk density of the product during dry mixing, were investigated. The influence of technological production modes on product quality indicators was studied. The nutritional value of dry mixtures of protein-carbohydrate drinks for sports nutrition was determined.

The technological requirements for the developed product were selected and systematized. The mass fraction of carbohydrates in the product was 59.8%; the carbohydrate component of the product includes mono- and polysaccharides in a ratio of 1:5; the mass fraction of proteins in the product was 33.2%; essential amino acids score in the protein complex is equal to or higher than one. The form of production of the product was a dry powder, which ensures the long-term preservation of the nutritional value and makes it possible to vary the calorie content and the number of incoming nutrients when consumed in the form of a drink.

In terms of safety (the content of toxic substances, pesticides, antibiotics, radionuclides), as well as microbiological indicators, the product meets the requirements for food products and the requirements of the Technical Regulations of the Customs Union "On the safety of food products", (TR TS 021/2011). According to the requirements, a daily serving of this product provides from 40 to 60% of the athlete's daily demand for complete protein and carbohydrates. Developed dry specialized protein-carbohydrate mixtures are suppliers of carbohydrates and proteins and also contain various flavoring substances.

### **Ethical issue**

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

# **Competing interests**

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

# **Authors' contribution**

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

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