Development of a product with increased nutritional density in compliance with macronutrient balance

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Abstract. The creation of a product with a balanced composition with increased food density and an optimal ratio of macronutrients, based on dairy raw materials, is a promising direction in the development of food technologies in the field of specialized nutrition. The object of the study was mixtures with an optimal ratio of protein, lipid and carbohydrate components equal to 1: 1: 4. In this case, the carbohydrate component of the product was additionally formed from raw materials of plant origin. Ingredients of Russian origin were used in the work. The organoleptic method was used to assess the consumer characteristics of freshly produced samples, as well as during their storage. There were no obvious differences in these indicators. In the samples put in storage, the physicochemical indicators were investigated: active acidity and viscosity. It is noted that an increase in viscosity is the result of stabilization of the product structure in comparison with its initial state, as a result of swelling of hydrocolloids. In the course of the work, the microbiological indicators of all samples were investigated. During the entire storage period, KMAFAAnM did not exceed the average values of 250-2800 CFU / g, which gives grounds to determine the recommended shelf life of the resulting product 15 days.

According to the concept of the optimal ratio of macronutrients in the diet, existing in modern nutritional science, between proteins, fats and carbohydrates (P: F: C) in energy terms, the ratio 12-14: 30: 56-58 should be observed [1]. In terms of the mass of macronutrients, this dependence is expressed by a simple formula P: F: C equal to 1: 1: 4. Such theoretical calculations are quite difficult to implement in practice, in real life, due to the variety of diets and the multicompound nature of their components. In this connection, according to foreign and domestic nutrition experts, there are significant shifts in the balance of macro- and micronutrients in the diet of the population, which ultimately lead to a number of nutritionally dependent diseases [2, 3].

Physical activity requires an increased content of food density of food and a certain ratio of nutrients [4, 5, 6].

Due to its full composition, high biological and nutritional value, milk is the optimal raw material for creating functional and specialized nutrition products. The study of the combination of dairy and non-dairy components is one of the leading trends in recent years in the development of the dairy industry in our country and abroad.

The purpose of this work is to develop a product with increased nutritional density in compliance with macronutrient balance.

A group of experts described the organoleptic characteristics of the product in terms of the main consumer indicators: taste and smell, colour, appearance and consistency. Physicochemical indicators: acidity, titratable and active, were analysed, respectively, by indicator and potentiometric methods. The
viscosity of the samples was investigated by the method of viscosimetry. Microbiological safety indicators were determined by inoculation on KMAFAnM nutrient medium.

To create a product with an optimal ratio of macronutrients equal to 1: 1: 4, between proteins, lipids and carbohydrates, we used skimmed milk powder with a mass fraction of dry matter 95.0%, cream and milk with a mass fraction of fat 35.0% and 2.5%, respectively, starch with mass fraction of dry substances 97.0%, berry syrup with a mass fraction of carbohydrates 65.0%, citric acid. To improve the consistency, a stabilizer based on guar and xanthan gums was used [7].

The optimal ratio of the protein, lipid and carbohydrate components in the developed product, equal to 7.5: 7.5: 30.0, was formed according to formulations 1 and 2, shown in Table 1, and was compared with a control sample, characterized by an increased content of dry substances in comparison with the experimental ones. In the manufacture of experimental product samples, an apparatus for thermomechanical processing was used. The components were emulsified at high frequencies (from 300 rpm to 1500 rpm) and heat treatment from 85 to 90 °C for 7.5 min.

Table 1. Recipe composition of mixtures.

| Name of raw materials | Weight in options, kg, according to recipe |
|-----------------------|------------------------------------------|
|                       | Control | Sample 1 | Sample 2 |
| Skimmed milk powder   | 27.0    | 17.7     | 17.7     |
| Cream                 | 26.4    | 30.0     | 30.0     |
| Milk                  | 13.2    | 25.8     | 25.8     |
| Starch                | 8.4     | 4.0      | 4.0      |
| Syrup                 | 24.7    | 22.2     | 22.2     |
| Lemon acid            | 0.3     | 0.2      | 0.3      |
| Stabilizer            | –       | 0.1      | –        |
| Total                 | 100.0   | 100.0    | 100.0    |
| Ratio F: P: C         | 10.0:10.0:40.0 | 7.5:7.5:30.0 | 7.5:7.5:30.0 |

The samples were evaluated by organoleptic and analytical methods. Freshly produced control and experimental samples were sweet, had a pronounced creamy smell and taste with a taste of pasteurization and fruit and berry component. The consistency of the samples was characterized as pasty, plastic, homogeneous, the product melted well in the mouth. The samples had a uniform, uniform color ranging from light yellow to cream.

To determine the shelf life of a product with a balanced composition with an increased food density for the nutrition of athletes, freshly developed samples of control, experiment 1 (with a stabilizer) and experiment 2 (without a stabilizer) were stored at (4 ± 2) °C.

Physicochemical parameters were studied in the obtained samples, put in storage. The results of changes in the active acidity and viscosity of the samples within 21 days are shown in figures 1 and 2, respectively.
Figure 1. Dynamics of active acidity of samples of a product of balanced composition with increased food density.

Figure 2. Changes in the viscosity of samples of a balanced composition with increased food density.

According to these data, it can be seen that during storage there is a tendency to a decrease in pH and an increase in the viscosity of the dairy compound product with syrup. An increase in viscosity is the result of stabilization of the product structure in comparison with its initial state, as a result of swelling of hydrocolloids.

During storage of the product, no significant changes in taste and smell were observed. The high content of carbohydrates in the product and the presence of citric acid in it, apparently, causes some preservative effect. However, the expert group noted a decrease in the intensity of the creamy taste in the samples. Also, in the control sample at the end of storage, the initial stage of crystallization of lactose was noted, so its consistency was assessed relatively worse. In prototypes 2 and 3, by the end of the expected shelf life, consistency deficiencies were not revealed. The colour of freshly produced samples...
and at the end of the estimated shelf life, regardless of the selected formulation, was characterized as creamy with a slight hint of syrup. The results of the sensory evaluation are presented in table 2.

**Table 2.** Tasting card of the results of organoleptic evaluation of a product of balanced composition with increased food density.

| Shelf life, days | Samples                        |
|-----------------|--------------------------------|
|                 | Control (10.0:10.0:40.0)       |
| 0               | 4.0±0.1                        |
| 7               | 3.7±0.1                        |
| 14              | 3.6±0.1                        |
| 21              | 3.6±0.1                        |
|                 | Experiment 1 (7.5:7.5:30.0)     |
|                 | with stabilizer                |
| 0               | 4.3±0.1                        |
| 7               | 4.3±0.1                        |
| 14              | 4.3±0.1                        |
| 21              | 3.7±0.1                        |
|                 | Experiment 2 (7.5:7.5:30.0)     |
|                 | without stabilizer             |
| 0               | 4.5±0.1                        |
| 7               | 4.5±0.1                        |
| 14              | 4.4±0.1                        |
| 21              | 4.1±0.1                        |

The results of changes in microbiological indicators of control samples of a balanced composition with increased food density, experiment 1 (with a stabilizer) and experiment 2 (without a stabilizer) during storage are shown in figure 3.

![Figure 3. Dynamics of changes in the content of KMAFAnM in samples of a product with a balanced composition with an increased food density during storage.](image_url)

Analysis of the above data indicates the absence of negative dynamics in the change in microbiological indicators during storage of a product of balanced composition with an increased food density at a temperature of (4±2) °C. During the entire study period, as can be seen from the data presented, KMAFAnM did not exceed the average values of 250-2800 CFU / g. Staphylococci and BGKP were not detected in 1 g of the product.

On the basis of the studies performed, a set of regulatory documents has been developed for the production of a dairy product with syrup for nutrition of athletes. The normative indicators for such a product can be set at the level of indicators for products obtained on the basis of cream, which makes it possible to determine the recommended shelf life of a product of a balanced composition with an increased food density, taking into account the reserve ratio for 15 days.

**References**

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