Evaluation of the quality, environmental safety and biological value of functional curd product

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Abstract. The authors conducted studies to assess the quality and calculation of biological value of the developed curd product. Estimation of organoleptic parameters was carried out with use of tasting scale of curd and curd products estimation, on the basis of which the profilogram was built and it was established that the developed curd product received the maximum quantity for taste and smell, appearance and consistency. Nutritional value of the experimental sample increased due to introduction of whey proteins and sesame seeds: protein (by 2.0%), appearance of carbohydrates (0.3%) and dietary fibers (0.05%). In the experimental sample the number of lactic acid microorganisms considerably exceeds both the normal values and the values of the control sample, which proves its probiotic properties and indicates a high physiological value. The calculated amino acid scoring of the eight essential amino acids is quite high and ranges from 105.9% valine to 191.0% tryptophan, which is well balanced and significantly exceeds the ideal protein. The biological value of the experimental sample with sesame seeds and whey proteins was 65.2%, the utility coefficient was 0.77, which indicates its high biological value and high balance of the amino acid composition.

1. Introduction

According to the estimates of global analytical agencies, the most promising area of development of the food industry at present is the production of functional foods. Their consumption level is approximately 150,000 tons per year in Europe and 1,500 tons per year in Russia. The relevance of healthy nutrition is confirmed by studies indicating a direct correlation between the immune status of the person and the food he consumes. Manufacturers expand the range of preventive products using various functional ingredients: dietary fiber, vitamins, antioxidants, polyunsaturated fatty acids, pre- and prebiotics [1, 2, 3].

The authors developed a functional cottage cheese product. Microflora of mesophilic lactic acid bacteria was used as a probiotic component. To improve the nutritional and biological value of the product a combination of vegetable (white sesame seeds) and dairy (whey concentrate) raw materials was used.
Sesame seeds (Sesamum indicum) contain 40-60% oil, represented by equal parts of oleic (from 35 to 54%) and linoleic (from 39 to 59%); besides, sesame seeds contain 10% palmitic acid and 5% stearic acid [4] contains a large amount of fats and proteins, vitamins A, B, E, C, PP, mineral substances (calcium, phosphorus, iron, potassium, magnesium, etc.). Sesame contains sesamine lignan, which serves as a powerful antioxidant, it is used in the prevention of cancer, reduces blood cholesterol levels [5]. Sesamol is a natural phenolic compound and the main lignan isolated from sesame seeds and sesame oil. There is evidence that sesamol acts as a metabolic regulator with antioxidant, antimutagenic, anti-hepatotoxic, anti-inflammatory, rejuvenating and chemopreventive properties and has anti-cancer effects. [6] The inhibitory effect of consumption of sesame seeds and their derivatives on oxidative stress in people with systemic arterial hypertension, dyslipidemia and type 2 diabetes was established [7]. Consumption of sesame seeds for 8 weeks promotes the absorption and accumulation of vitamin E isoforms - alpha - and gamma-tocotrienols, as well as gamma-tocopherol in adipose tissue and skin (P < 0.05) [8]. The use of sesame seeds in the diet improves spatial cognitive abilities, increases the concentration and activity of superoxide dismutase, catalase and glutathione peroxidase, and reduces the level of malonic dialdehyde in the hippocampus. It increases neuronal integrity, decreases the apoptotic index, decreases the expression of pro-apoptotic protein Bax and increases the expression of anti-apoptotic protein Bcl-2 in CA1 hippocampal neurons, which allows using this product in neurodegenerative diseases and encephalopathies of various genesis [9, 10, 11].

Reducing the amount of protein in food rations negatively affects human health, reduces its resistance to adverse external influences [12, 13], and leads to impaired absorption of riboflavin, nicotinic and ascorbic acids. In this regard, special attention was paid to non-traditional sources of animal protein, one of which is whey. The main component of whey protein that has an important nutritional value is whey protein, which is formed after casein precipitation from milk by acid at pH 4.6-4.7. On average, serum contains 0.6% proteins. The composition of whey protein is represented by the following types of proteins: β-Lactoglobulin, α-Lactalbumin, bovine serum albumin, lactoferrin, glycomacropeptides, immunoglobulins, lactoperoxidases and protease-peptones, and other valuable food components [14]. Whey protein has not only an important nutritional value, but is also used in dietary corrections of pathological processes. The use of whey protein in the diet of cancer patients significantly alleviates cancer cachexia syndrome. The usefulness of whey protein is confirmed by its high leucine content and ability to modulate IGF-1 (insulin-like growth factor) concentration, which prevents musculoskeletal hypotrophy [15]. Protein fraction of whey protein - α-lactalbumin suppresses hunger, promotes weight loss in obesity, and improves glucose tolerance in diabetic patients [16]. Fraction of whey protein - lactoferrin improves gut microbiota, reduces liver lipidosis and mesenteric fat, and increases glucose tolerance [17]. Lactoferrin supplementation for 8 weeks 27, reduced the degree of visceral obesity in patients without changing caloric intake. Reduced caloric intake with the whey protein-based diet is associated with increased circulating concentrations of lower intestinal satiety hormones, including glucagon-like peptide-1 (GLP-1) and pancreatic peptide [18, 19].

Thus, the use of sesame seeds and whey proteins in the production of functional curd product designed for all consumer groups is relevant and appropriate. In view of the above, the purpose of the work is to study the qualitative indicators of the developed curd product and evaluation of its biological value.

2. Materials and methods
The objects of research were samples of cottage cheese products developed with the addition of functional ingredients and the control sample - cottage cheese product developed in accordance with State Standard 31453-2013 “Cottage cheese. Technical conditions”.

When organizing and conducting research used a set of common, standard and modified methods of research: determination of the mass fraction of fat - State Standard R ISO 2446-2011; determination of protein - Kjeldahl method according to State Standard 34454-2018; thermogravimetric method to determine the mass fraction of dry substances in cottage cheese products according to State Standard
28561-90; vitamin C content - titrometric method according to State Standard 24556-89; organoleptic evaluation was carried out in accordance with State Standard R ISO 22935-2-2011 and State Standard 33630-2015; microbiological indicators were determined according to State Standard 32901-2014. The content of amino acids, vitamins and minerals was determined by capillary electrophoresis using a drop-105M system. Statistical processing of the obtained data and construction of mathematical models was carried out using the software package Statistica 6.0.

3. Results and discussion
The authors evaluated the quality of curd products and determined organoleptic, physico-chemical, microbiological and safety indicators, vitamin-mineral and amino acid composition and calculated biological value.

To assess the organoleptic characteristics, we used a tasting scale for evaluating curd and curd products, presented in Table 1.

| Table 1. Tasting scale for evaluating cottage cheese and cottage cheese products. |
|------------------|------------------|
| **Product performance, overall score** | **Discount, point** | **Score, point** |
| Taste and smell |  | |
| Very good: clean, sour milk, with no extraneous flavors and odors, with a slight taste of pasteurization, for curds using dried milk - with a taste of dried milk, for curds and cottage cheese products using fillers with the flavor and smell of the filler introduced. | 0 | 5 |
| Good: With no more than one of the following signs: sour taste, whey flavor, nutty flavor (for curds without fillers), slightly foddery | 1 | 4 |
| Satisfactory: the simultaneous presence of not more than 2 of the following signs: characteristic for cottage cheese taste and smell expressed weakly, there is a yeasty smell and taste, excessively sour, slight bitterness. | 2 | 3 |
| Bad and very bad, depending on the severity of the defect: taste and smell - not characteristic of the product, there are pronounced foreign flavors and smells (at least one): feed, musty, oxidized, bitter, rancid, ammonia, metallic, etc. | 3 | 2 |
| Appearance and consistency |  | |
| Very good: homogeneous, soft, slightly smeared, crumbly, with or without perceptible particles of milk protein. In a product with filler the presence of particles of filler. For a non-fat product, slight whey secretion | 0 | 3 |
| Good: the presence of no more than 2 of the following signs: smeary, slight grittiness, slight flouriness. For a nonfat product, noticeable whey separation. | 1 | 2 |
| Satisfactory: the presence of not more than 2 of the following features: loose, excessively crumbly, slightly heterogeneous, perceptible grittiness, weakly rubbery. For nonfat product - considerable separation of whey | 2 | 1 |
| Bad and very bad: depending on the severity of malformations: pronounced rubbery, lumpy, rough, crumbly, excessively smeared, slimy, strong secretion of whey, etc. | 3 | 0 |
| Colour |  | |
| Satisfactory: white to light creamy, uniform in mass or due to the color of the added filler. | 0 | 1 |
| Unsatisfactory: uneven throughout the mass | 1 | 0 |

Note: The maximum number of points is 10, of which: 5 - taste and smell, 3 - appearance and consistency, 1 - color, 1 - packaging and labeling.
Table 2 shows the organoleptic characteristics of the developed curd drinks.

**Table 2. Organoleptic characteristics of developed curd products.**

| Indicator name | Control sample | Experimental sample (with sesame seeds and whey proteins) |
|----------------|----------------|----------------------------------------------------------|
| Appearance and consistency | Soft, spreadable, slightly crumbly consistency | Soft, slightly crumbly consistency with the presence of single sesame seeds |
| Taste and smell | Pure, sour milk with a faintly pronounced taste of pasteurization | Pure, sour milk with a distinct flavor, harmoniously combined pasteurized milk and sesame seeds |
| Colour | Milky white uniform throughout | Light creamy, with isolated flecks of sesame seeds and whey proteins, evenly distributed throughout the mass |

The table shows that the organoleptic characteristics are high enough, do not have a sharply expressed taste and smell, which will allow their use by different groups of people, both children and the elderly. On the basis of the results obtained, a profilogram of censoring organoleptic characteristics of curd products was built. It was established that the developed curd product got 10 points in comparison with the control sample, which got 8 points, the enriched product got higher marks for taste and smell and appearance and consistency.

The chemical composition, microbiological indicators, safety indicators and calculated energy value of curd products were determined (Table 3).

**Table 3. Nutritional and energy value of cottage cheese products.**

| No. | Indicator name | Control sample | Experimental sample |
|-----|----------------|----------------|---------------------|
| 1   | Mass fraction of fat, not less % | 20.0 | 20.0 |
| 2   | Mass fraction of protein, not less % | 8.0 | 10.0 |
| 3   | Mass fraction of carbohydrates, g including mass fraction of dietary fiber, g | - | 0.3 |
|     | Mass fraction of moisture, not more % | - | 0.05 |
| 4   | Titratable acidity, °T | 72.0 | 69.65 |
| 5   | Phosphatase | not available | |
| 6   | Temperature when leaving the plant, °C | 4 ± 2 | |
| 7   | Energy value, kcal | 212.0 | 221.2 |

Analysis of the table showed that the nutritional value of the experimental sample increased due to the increased protein by 2.0% due to the introduced whey proteins and the appearance in the experimental sample of carbohydrates (0.3%) and dietary fiber (0.05%) and sesame seeds, which give the product a functional orientation. The developed product is characterized by moderate acidity and increased caloric content by 9.2 kcal due to the appearance of carbohydrates and increased protein content.

Microbiological indicators and safety indicators are of great importance in the production of curd products, as they characterize the safety of curd products. The results are presented in Table 4 and Table 5.
Table 4. Microbiological parameters of curd products.

| No. | Indicator name                                                                 | Standard according to TR CU 033/2013 | Control sample | Experimental sample |
|-----|-------------------------------------------------------------------------------|--------------------------------------|----------------|---------------------|
| 1   | Lactic acid microorganisms, CFU/cm³ (g), not less (at the end of storage life) | 1 × 10⁶                              | 1.7 × 10⁶      | 4.3 × 10⁶           |
| 2   | Weight of the product cm³ (g) in which is not allowed                          | 0.1                                  |                |                     |
|     | E. coli bacteria (coliforms)                                                   | 1.0                                  |                |                     |
|     | S. aureus                                                                     | 1.0                                  |                |                     |
|     | Pathogens, including                                                          |                                      |                |                     |
|     | Salmonella                                                                    |                                      |                |                     |
| 3   | Yeast, CFU/cm³ (g), not more                                                  | 25                                   | not detected   | not detected        |
| 4   | Molds, CFU/cm³ (g), not more                                                  | 50                                   | 18             | 14                  |

Analysis of the Table 4 showed that the number of lactic acid microorganisms in the experimental sample significantly exceeds both the standardized values and the values of the control sample, which proves its probiotic properties and indicates a high physiological value. Disease-causing microorganisms such as E. coli bacteria, Staphylococcus aureus and Salmonella bacteria were not detected in the samples of sour-milk products. The number of yeast and mold cells does not exceed the values regulated by the Technical Regulation of the Customs Union TR CU 033/2013 "On safety of milk and dairy products" for this group of dairy products.

The study of safety indicators examined the presence of toxic elements, mycotoxins, pesticides, radionuclides, antibiotics, etc. (Table 5).

Table 5. Safety indicators of fermented dairy products.

| Name indicator                      | Permissible level | Index value, mg/kg (for radionuclides - Bq/kg) |
|------------------------------------|-------------------|-----------------------------------------------|
|                                    |                   | Control sample | Experimental sample |
| **Toxic elements**                 |                   |                |                    |
| Lead                               | 0.1               | 0.04           | 0.03               |
| Arsenic                            | 0.01              | 0.01           | 0.01               |
| Cadmium                            | 0.01              | 0.01           | 0.01               |
| Mercury                            | 0.001             | 0.0001         | 0.0001             |
| **Pesticides**                     |                   |                |                    |
| Hexachlorocyclohexane (α-, β-γ-isomers) | 0.05         | 0.03           | 0.03               |
| DDT and its metabolites            | 0.05              | 0.01           | 0.01               |
| **Antibiotics**                    |                   |                |                    |
| Levomycetin                        | is not allowed    |                 |                    |
| Tetracycline group                 | is not allowed    |                 |                    |
| Streptomycin                       | is not allowed    |                 |                    |
| Penicillin                         | is not allowed    |                 |                    |
| **Mycotoxins**                     |                   |                |                    |
| Aflatoxin M₁                       | 0.0005            | 0.0001         | 0.0001             |
| **Radionuclides**                  |                   |                |                    |
| Cesium-137                         | 100               | 76             | 74                 |
| Strontium-90                       | 25                | 11             | 10                 |
The results of the study of safety parameters of curd products, presented in Table 5, show that the content of toxic elements, nitrates, radionuclides and mycotoxins in the experimental and control samples meet the requirements of the Technical Regulations of the Customs Union "On safety of milk and dairy products" (TR CU 033/2013), their values do not exceed the allowable level. A very important factor for functional curd products is the presence of vitamins, minerals, amino acids, as well as prebiotic substances that give the product a functional orientation. The vitamin and mineral composition of curd products was determined for the final estimated shelf life. The results are presented in Table 6.

### Table 6. Mineral composition of cottage cheese products, g/100 g of the product.

| No. | Indicator name        | Control (cottage cheese without additives) | Enriched cottage cheese product | Deviations, +/- |
|-----|-----------------------|---------------------------------------------|----------------------------------|-----------------|
| 1   | Calcium, g/100 g of product | 0.13±0.02                                   | 0.16±0.01                       | +0.03           |
| 2   | Potassium, g/100 g    | 0.47±0.01                                   | 0.52±0.01                       | +0.05           |
| 3   | Phosphorus, g/100 g   | 0.29±0.01                                   | 0.35±0.01                       | +0.03           |
| 4   | Magnesium, g/100 g    | 0.12±0.01                                   | 0.15±0.01                       | +0.03           |
| 5   | Sulfur, g/100 g       | 0.22±0.01                                   | 0.24±0.01                       | +0.14           |
| 6   | Selenium, g/100 g     | -                                           | 0.0013±0.001                    | +0.0001         |
| 7   | Zinc, g/100 g         | 0.036±0.02                                  | 0.037±0.01                      | +0.01           |
| 8   | Copper, g/100 g       | 0.02±0.01                                   | 0.06±0.01                       | +0.004          |
| 9   | Cobalt, g/100 g       | 0.002±0.01                                  | 0.003±0.01                      | +0.001          |
| 10  | Iron, g/100 kg        | 0.036±0.02                                  | 0.037±0.001                     | +0.001          |
| 11  | Iodine                | -                                           | 0.001                           | +0.001          |

As can be seen from the table, the increase in the mineral composition occurs in the experimental curd product for almost all macro- and microelements due to the introduction of sesame seeds and whey proteins, so the increase in magnesium occurred by 25%, calcium - by 23%, phosphorus - by 21%, potassium - by 10%, sulfur - by 9%, appeared in enriched curd such important microelements as iodine and selenium, selenium is necessary for iodine assimilation and normal development of the body. The vitamin composition of curd products is presented in Table 7.

The vitamin composition of the cottage cheese product is quite diverse and contains both water-soluble and fat-soluble substances. Analysis of the table showed that the enriched product had an increase in vitamins of almost all types, especially for vitamins such as choline - by 40%, C - by 33.3%, B1 - 20%. So, quite a lot of ascorbic acid in the product, which is the recognized leader among antioxidants, which helps to extend youth and preserve beauty. To cover the daily requirement of ascorbic acid is enough to eat 200 grams of this product every day. The composition of vitamins in cottage cheese also includes rutin, a substance needed to strengthen the walls of blood vessels, especially useful for the health of people with varicose veins and fragile capillaries.
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Table 7. Vitamin composition of cottage cheese products, mg/100 g product.

| No. | Amino Acids                  | Control         | Enriched cottage cheese product | Deviations, +/- |
|-----|------------------------------|-----------------|---------------------------------|-----------------|
| 1   | Vitamin B1 (thiamine)        | 0.04±0.02       | 0.048±0.01                      | +0.44           |
| 2   | Vitamin B2 (riboflavin)      | 0.25±0.01       | 0.253±0.01                      | +0.003          |
| 3   | Vitamin B3 (nicotinic acid)  | 0.20±0.01       | 0.21±0.01                       | +0.01           |
| 4   | Vitamin B4 (pyridoxine)      | 0.19±0.01       | 0.20±0.01                       | +0.01           |
| 5   | Vitamin B5 (folic acid)      | 0.04±0.01       | 0.05±0.01                       | +0.01           |
| 6   | Vitamin PP (nicotinic acid)  | 4.00±0.01       | 4.05±0.001                      | +0.05           |
| 7   | Vitamin C (ascorbic acid)    | 0.36±0.02       | 0.48±0.01                       | +0.12           |
| 8   | Vitamin D (alpha-tocopherol) | 0.02±0.01       | 0.023±0.01                      | +0.003          |
| 9   | Vitamin E                   | 0.036±0.02      | 0.037±0.01                      | +0.001          |
| 10  | Choline                      | 0.02±0.01       | 0.28±0.01                       | +0.08           |

Next, the amino acid composition of curd products was determined (Table 8).

Table 8. Amino acid composition of cottage cheese products.

| Amino Acids                  | Control sample, g/100g protein | Experimental sample, g/100g protein | Deviations, +/- |
|------------------------------|---------------------------------|------------------------------------|-----------------|
| Essential amino acids        |                                 |                                    |                 |
| Arginine                     | 3.3±0.02                        | 3.37±0.02                          | + 0.07          |
| Valin                        | 5.4±0.02                        | 5.51±0.02                          | + 0.11          |
| Histidine                    | 2.4±0.01                        | 2.52±0.01                          | + 0.12          |
| Isoleucine                   | 5.0±0.02                        | 5.13±0.02                          | + 0.13          |
| Leucine                      | 9.1±0.02                        | 9.37±0.02                          | + 0.27          |
| Lysine                       | 8.5±0.02                        | 8.71±0.02                          | + 0.21          |
| Methionine                   | 2.6±0.01                        | 2.65±0.02                          | + 0.05          |
| Threonine                    | 4.5±0.02                        | 4.59±0.02                          | + 0.09          |
| Phenylalanine                | 4.4±0.02                        | 4.49±0.02                          | + 0.09          |
| Tryptophan                   | 1.8±0.01                        | 1.91±0.01                          | + 0.01          |
| Total essentials             | 47.0                            | 48.58                              | + 1.58          |

| Substitutable amino acids    |                                 |                                    |                 |
| Alanine                      | 3.4±0.02                        | 3.51±0.02                          | + 0.11          |
| Aspartic acid                | 7.6±0.02                        | 7.82±0.02                          | + 0.22          |
| Glycine                      | 1.8±0.01                        | 1.85±0.01                          | + 0.05          |
| Prolin                       | 9.7±0.02                        | 9.83±0.02                          | + 0.13          |
| Serin                        | 5.3±0.02                        | 5.39±0.02                          | + 0.09          |
| Tyrosine                     | 4.7±0.02                        | 4.77±0.02                          | + 0.07          |
| Cystine                      | 0.9±0.01                        | 0.97±0.01                          | + 0.07          |
| Total substitutable           | 33.4                            | 34.65                              | + 1.25          |
| amino acids                  |                                 |                                    |                 |
| Total amino acids            | 80.4                            | 83.23                              | + 2.83          |

Analysis of the table showed that the experimental sample of cottage cheese product contains 3.7% more of all amino acids than the control sample, 3.4% more of essential amino acids and 3.74% more of substitutable amino acids. The results show that the product is rich in amino acids, both quantitatively and qualitatively.
As can be seen from the figure, each essential amino acid exceeds its values compared to the control sample, indicating that the enrichment of the curd product with sesame seeds and whey proteins leads to positive results, which contributes to a beneficial effect on the human body.

And in Table 8 we observe that there was a significant increase in the substitutable amino acids for all the items, which is also beneficial and beneficial for the human body when the enriched curd products are regularly consumed.

To assess the biological value of curd products, its amino acid composition is compared with the amino acid composition of the ideal protein by determining the amino acid score.

One accessible way to calculate the amino acid score is to calculate the ratio of the amount of each essential amino acid in the test protein to the amount of that amino acid in the ideal protein (formula 1):

\[
\text{Amino acid grading} = \frac{\text{mg essential amino acids in 1 g of test protein}}{\text{mg essential amino acids in 1 g of ideal protein}} \times 100
\]

where \( \text{mg essential amino acids in 1 g of test protein} \) is the content of an essential amino acid in 1g of the protein under study, mg; \( \text{mg essential amino acids in 1 g of ideal protein} \) is content of the same amino acid in 1g of "ideal" (standard) protein, mg; 100 - conversion coefficient in percent.

The limiting amino acid of biological value is the one with the lowest scoraption.

Amino Acid Score Difference Factor (ASDF), numerical characteristic of the imbalance of essential amino acids in relation to the physiologically necessary norm (standard), was calculated by formula 2:

\[
\text{ASDF} = \frac{\sum_{i=1}^{n} \Delta ACD}{n},
\]

where \( \Delta ACD \) – the difference of the amino acid scoring of an amino acid, which is determined by formula 3:

\[
\Delta ACD = S_i - S_{\text{min}},
\]

where \( S_i \) – excess score i-th essential amino acid, %; \( S_{\text{min}} \) – is the minimum of the scores of the essential amino acid of the protein under study relative to the reference, %; \( n \) - amount of essential amino acids.

The value of biological value (BV) is determined by formula 4:

\[
BV = 100 - \text{ASDF}.
\]

To assess the balance of essential amino acids in relation to the reference protein, a utility coefficient \( K_i \) is calculated according to formula 5:

\[
K_i = \frac{AC_{\text{min}}}{AC_i},
\]

where \( AC_i \) is the amino acid score of the i-nonessential amino acid in the enriched product; \( AC_{\text{min}} \) is the amino acid score of the first limiting amino acid in the product.

The amino acid composition utility ratio (U) was calculated according to formula 6:

\[
\text{ASDF} = \frac{\sum_{i=1}^{n} (A_i K_i)}{\sum_{i=1}^{n} A_{i,cr}},
\]

The results of calculations of the biological value of curd products are presented in Table 9.

The Table 9 shows that the amino acid score of the developed product is high enough for eight essential amino acids and ranges from 105.9% valine to 191.0% tryptophan. The limiting amino acid is phenylalanine at 93.5%.
Evaluating the quality of the proteins of the products produced by the amino acid scoring method, it can be noted that they are well-balanced. Thus, the optimal content of particularly scarce amino acids, such as leucine, lysine and tryptophan amino acid scoring is much higher than the ideal protein.

The calculation of biological value of the control sample of curd products was 67.4%, and the experimental sample with sesame seeds and whey proteins was 65.2%, which indicates a high biological value of the developed curd product.

| Name       | AO reference, mg/1g protein | Curd product, (mg/1g) | % | ΔACD | ASDF | BV | Ki | U | Functional product, (mg/1g) | % | ΔACD | ASDF | BV | Ki | U |
|------------|-----------------------------|-----------------------|----|------|------|----|----|---|-----------------------------|----|------|------|----|----|---|
| Valine     | 5.2                         | 103.8                 | 12.2 | 0.88 |       |    |    |   | 5.51                         | 105.9 | 12.4 | 0.88 |
| Histidine  | 1.8                         | 133.3                 | 41.7 | 0.69 |       |    |    |   | 2.52                         | 140.0 | 46.5 | 0.67 |
| Isoleucine | 4.6                         | 108.7                 | 17.0 | 0.84 |       |    |    |   | 5.13                         | 111.5 | 18.0 | 0.84 |
| Leucine    | 6.9                         | 131.9                 | 40.2 | 0.70 |       |    |    |   | 9.37                         | 135.8 | 42.3 | 0.69 |
| Lysine     | 5.5                         | 154.5                 | 62.9 | 0.59 |       |    |    |   | 8.71                         | 158.4 | 64.9 | 0.59 |
| Methionine | 2.8                         | 92.9                  | 1.2  | 32.6 | 67.4 | 0.99| 0.77|   | 2.65                         | 94.6  | 1.1  | 34.8 | 65.2 | 0.99| 0.77|
| Threonine  | 3.7                         | 121.6                 | 30   | 0.75 |       |    |    |   | 4.59                         | 124.1 | 30.6 | 0.75 |
| Phenylalanine | 4.8                     | 91.7                  | 0    | 1    |       |    |    |   | 4.49                         | 935   | 0    | 1   |
| Tryptophan | 1.0                         | 180.0                 | 88.3 | 0.51 |       |    |    |   | 1.91                         | 191.0 | 97.5 | 0.49 |
| Total      | 1118.5                     | 293.5                | 6.95 | 44.88| 1154.9| 313.0| 6.90|

Table 9. Results of calculations of indicators of biological value of curd products.

Calculation of the utilitarian coefficient of amino acid composition (U) shows that both the control and the experimental sample have the same value (0.77), due to the fact that all amino acids of the developed curd product, including the limiting amino acid (phenylalanine) increased by 1.87%. Utility coefficient characterizes the balance of the amino acid composition, the better-balanced amino acids in protein, the more rationally they can be used by the body.

Based on all of the above, it follows that cottage cheese product enriched with sesame seeds and whey proteins is a high-quality product, balanced by chemical, vitamin-mineral and, especially, amino acid composition, which together characterize its high biological value.

4. Conclusion
The authors conducted research to assess the quality of the developed curd product and calculated its biological value. When evaluating organoleptic indicators, it was found that the developed curd product got the maximum number of 10 points compared to the control sample, which received 8 points, higher scores were given to the enriched product for taste and smell, appearance and consistency. The chemical composition, microbiological indicators, safety indicators and calculated energy value of cottage cheese products were determined. It was found that the nutritional value of the experimental sample increased due to the increase of protein by 2.0% due to the introduced whey proteins and appearance of carbohydrates (0.3%) and dietary fiber (0.05%) in the experimental sample.
due to sesame seeds, which increased the energy value by 9.2 kcal. Evaluation of microbiological parameters made it possible to establish that the number of lactic acid microorganisms in the experimental sample significantly exceeds both normalized indicators and values of the control sample, which proves its probiotic properties and indicates a high physiological value. The study of vitamin and mineral and amino acid composition has shown an increase in all macro- and microelements in the developed product: magnesium - by 25%, calcium - by 23%, phosphorus - by 21%, potassium - by 10%, sulfur - by 9%; iodine and selenium are revealed. The vitamin composition of the cottage cheese product is quite diverse and the developed product showed an increase in all vitamins: for example, choline by 40%, C by 33.3%, B1 by 20%.

The amino acid composition of the enriched curd product increased by 3.7 %, 3.4 % more essential amino acids and 3.74 % more substitutable amino acids. When assessing the biological value, it was found that the amino acid content of eight essential amino acids is high enough and ranges from 105.9% valine to 191.0% tryptophan. The limiting amino acid is phenylalanine - 93.5%. The calculation of the biological value of the control sample of curd products was - 67.4%, and the experimental sample with sesame seeds and whey proteins was - 65.2%. Calculation of the utilitarian coefficient of amino acid composition shows that both the control and experimental samples have the same value (0.77). Utility coefficient characterizes the balance of the amino acid composition, the better the balance of amino acids in protein, the more rational they can be used by the body.

Based on all of the above, it follows that cottage cheese product enriched with sesame seeds and whey proteins is a high-quality product, balanced by chemical, vitamin-mineral and, especially, amino acid composition, which together characterize its high biological value.

Thus, the useful properties of the curd product can become the main factor for its promotion strategy in the market of functional foods, and the introduction of the developed technology at the dairy enterprises will expand the assortment of curd products aimed at solving the problem of satisfying the population with wholesome food products.

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