Brine-ripened cheese enriched with vegetable ingredients: technology and quality

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Abstract. Paprika, coriander seeds, and β-carotene have been theoretically substantiated and practically proved to be appropriate to use in brine cheese production as functional ingredients rich in vitamins, macro- and microelements, dietary fiber, and essential amino and fatty acids with health-promoting properties. The preparation method and technological point to introduce herbal ingredients have been established; the probiotic complex that is necessary for the cheese production has been selected. The cheese technology has been developed, and its quality was assessed. Sensory characteristics were harmonious; the taste, odor, and pattern of the cheese product were pleasant to perceive. The product was protein/fat balanced; dietary fibers satisfied the recommended norm for 28%. There was an increase in minerals 2.5 times (potassium, iron, magnesium, and phosphorus) and vitamins by 70.0% (β-carotene, vitamin A, E, B6, B5); trace element selenium and vitamins K, B3, B4, and α-carotene appeared, which led to an increase in the biological value of the cheese product.

1. Introduction
Cheese-making is known to be one of the most reliable and convenient methods of converting milk into a product that is well and long-term stored and less voluminous, since it contains more than a third less water and is high in calories due to a considerable amount of fat and protein. For a balanced nutrition of the population, cheese is a very useful product due to a vitamin-mineral complex, and amino and fatty acids, necessary to meet the needs of the body [1, 2].

The functional dairy products market is one of the fastest growing segments where innovation is the key to success [3]. To develop a cheese product, we chose coriander, paprika, and beta-carotene as functional ingredients.

Coriander (Coriandrum sativum L.) is a well-known plant used in nutrition, folk medicine, and pharmacy due to components that have a beneficial effect on our body—alkaloids, fructose, glucose, fixed oils, tanning components, pectin, starch, and many vitamins. Coriander is a promising source of lipids (petrozelinic acid), has a wide spectrum of pharmacological activity, i.e., antibacterial,
antioxidant, antidiabetic, anxiolytic, antiepileptic, antidepressant, antimutagenic, anti-inflammatory, antidysslipidemic, hypotensive, and neuroprotective activities [4]. Coriander seed oil is the second most important essential oil, active against bacteria, some yeast, dermatophytes, and filamentous fungi [5]. Coriander extract used in diet was found to reduce lipid peroxidation, improve the overall lipid profile, and modulate the expression of endothelin receptors. Coriander extract applied in treatment of heart failure in rats led to a significant improvement in left ventricular function and hemodynamic parameters [6, 7].

Paprika is red sweet pepper (Capsicum annuum L.) and a source of phenylols and bioflavonoids. It contains carotene, rutin, vitamins A, B1, B2, B5, B6, B9, C, E, and PP, as well as macro- and microelements (potassium, calcium, magnesium, phosphorus, sodium, zinc, selenium, copper, manganese, iron, sulfur, etc.). Paprika has a whole range of useful substances that activate metabolic processes in the body, increase immunity, help strengthen the mucous membranes, positively affect the activity of the gastrointestinal tract, and more intensively inhibit lipid peroxidation [8, 9]. Pepper extracts have a pronounced antihyperglyco-lipidemic effect and antioxidant and antiradical activity and can be useful in preventing or slowing various diseases associated with oxidative stress [10].

β-carotene is used in food industry as a safe natural dye that gives foodstuffs various color shades from pale yellow to saturated orange. It has no hypervitamin activity, characteristic of vitamin A. β-carotene has an antioxidant function and antiapoptotic action, so it is considered the main retinol precursor [11]. A decrease in the β-carotene concentration in blood causes visual dysfunction and an increase in endothelial adhesion molecules and blood sugar and insulin concentrations. It also provokes endothelial dysfunction and oxidative stress [12].

Thus, coriander seeds, paprika, and β-carotene that have a high content of vitamin-mineral complex and a wide range of therapeutic and prophylactic effects are appropriate to use in production of domiati brine-ripened cheese product.

The purpose of the work was to theoretically justify paprika, coriander seeds, and β-carotene to be used in cheese production, develop a technology of an enriched domiati cheese product, and assess its quality.

2. Materials and methods
The study objects were coriander seeds, dried paprika, and β-carotene, and cheese samples produced with different doses of plant ingredients and by various methods of adding them to the milk base. The research applied a set of generally accepted, standard, and modified research methods, i.e., determination of fat content according to GOST R ISO 2446-2011; protein determination by the Kjeldahl method according to GOST 34454-2018; determination of dry substance by accelerated method according to GOST 3626-73; sensory evaluation in accordance with GOST R ISO 22935-2-2011; microbiological analysis to GOST 32901-2014; and determination of the content of vitamins and minerals by capillary electrophoresis on the Kapel-105M system. The obtained statistical data were processed and mathematical models were constructed by the software package Statistica 6.0.

3. Results and discussion
At the first stage of the research, we analyzed the literature and patents on the issue under study.

At the second stage, consumer properties and chemical and vitamin-mineral compositions of paprika and coriander were studied. The vegetable ingredients were found to be rich in vitamins, macro- and micronutrients, dietary fiber, essential amino and fatty acids, especially omega-6 that contribute to the improvement of the cardio vascular system and gastrointestinal tract, facilitates and accelerates the removal of toxins from the body, and strengthens the immune system. The ingredients used as fortifiers are relevant and appropriate, since 75% of vitamins and minerals of milk remain in whey and do not get into cheese. So, paprika and coriander as fortifiers will help increase the nutritional and biological values of the product.

At the third stage, the effect of heat treatment on the microbiological parameters of the plant ingredients was studied. Before being added to the milk base, the plant components must be obligatory
heat treated in any way, since foreign microflora can lead to disorder in the development of the starter culture, unpleasant foreign tastes and smells, an unusual pattern, gas, and deformation of the block of cheese during ripening and storage. For the treatment, we heated milk to a temperature of 65±2°C, 73±2°C, and 82±2°C, added coriander seeds and dry paprika separately, kept for 25-30 minutes, cooled to 33-34°C, and determined microbiological and sensory points (table 1).

**Table 1.** Dependence of microbiological points of heat-treated plant ingredients on temperature.

| Parameter | Norm TR CU 33/2013 | Number of microorganisms at different temperatures of heat treatment, CFU/g |
|-----------|---------------------|------------------------------------------------------------------------------|
| Quantity of Mesophilic Aerobic and Facultative Anaerobic Microorganisms (QMAFAnM), CFU/g | Not more than $1 \times 10^4$ | 2x$10^2$ | not found | not found | 3x$10^3$ | not found | not found |
| Product weight (g) that does not allow | Coliform bacteria | 0.1 | 0.5 | not found | not found | 1.0 | not found | not found |
| | Staphylococcus S.aureus | 1.0 | not found | not found | not found | not found | not found | not found |
| | Pathogenic (incl. salmonella) | 25 | not found | not found | not found | not found | not found | not found |
| Yeast, CFU / cm$^3$ (g), not more than | 50 | 55 | 17 | 11 | 58 | 18 | 12 |
| Mold, CFU / cm$^3$ (g), not more than | 50 | 58 | 10 | 13 | 59 | 21 | 14 |

Table 1 shows that after paprika and coriander seeds being treated with milk heated to a temperature of 65±2°C, microorganisms of QMAFAnM ($2-3 \times 10^2$), Coliform bacteria, mold, and yeast remained alive in the milk. After 73±2°C and 82±2°C treatments, foreign microflora perished. Thus, the optimum temperature of milk in processing plant components is 73±2°C that kills foreign microflora and allows preserving useful substances. Moreover, sensory characteristics of paprika and coriander seeds improved; vegetable components softened and became tender with a delicate aroma and pleasant taste.

There were determined rational technological modes of cheese production and doses of introduced components, depending on the sensory properties and requirements of regulatory documents for cheese products. The obtained results enabled developing a technological scheme of the “Donskaya” domiata cheese product (figure 1).
Figure 1. Technological scheme for production of “Donskaya” domiati cheese product enriched with plant ingredients.

For the technology of a domiati cheese product, of great importance is the starter culture microflora that gave a certain taste, aroma, and pattern of cheese. A starter was selected, and direct-iophilized FD-DVS starter culture was found to develop higher quality characteristics of the cheese. The Flora-Danica culture is a mesophilic, heteroenzymatic aroma culture of LD type that includes strains of Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. lactis, Leuconostoc mesenteroides subsp. remorii, and Lactococcus lactis subsp. lactis biovar diacetylactis.

To determine the method and technological point for adding paprika and coriander seeds, we conducted a study. Paprika and coriander seeds were added to water and milk heated to 73±2°C, kept for 20-30 minutes, and cooled to a temperature of 33-34°C. Then the prepared supplements were added in two options. Option 1: when preparing the milk base for the coagulation process; and Option 2: after coagulation, in stirring the clot cut. The quality points of the cheese product were determined. The experiment found that paprika and coriander must be introduced into milk heated to 73±2°C before coagulation, according to Option 1, since in stirring the prepared milk, the vegetable components were evenly distributed throughout the mass, useful substances were preserved, which resulted in a beautiful cheese pattern. β-carotene acted as a safe natural dye that gave the product a yellowish tint and was added to milk being prepared for coagulation.
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The quality and safety of the cheese produced according to the developed technology were assessed. The results are presented in table 2.

**Table 2.** Qualitative points of the domiati “Donskaya” cheese product.

| Indicators                              | Characteristics                                                                 |
|----------------------------------------|-----------------------------------------------------------------------------|
| Weight fraction of protein, %          | Nutritional and energy values                                               |
| Control                                | Prototype                                                                  |
| 20.1                                   | 20.3                                                                       |
| Weight fraction of fat, %              |                                                                             |
| 17.8                                   | 18.1                                                                       |
| Weight fraction of moisture, %         |                                                                             |
| 53.4                                   | 52.6                                                                       |
| Weight fraction of carbohydrates, %    |                                                                             |
| 0.7                                    | 0.8                                                                        |
| Dietary fiber, g                       |                                                                             |
| not found                              | 0.6                                                                        |
| Ash, %                                 |                                                                             |
| 8.0                                    | 8.2                                                                        |
| Calories, kcal                         |                                                                             |
| 243.4                                  | 246.6                                                                      |

Sensory characteristics of “Donskaya” domiati cheese product

| Appearance                              | No heel, the outer layer is close, the surface is even. The section shows inclusion of introduced components |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------|
| Texture                                 | Hard, slightly brittle                                                                               |
| Colour                                  | Yellowish, nonuniform, with single pieces of reddish paprika and brown coriander seeds                |
| Pattern                                 | On a section, eyes are round and oval in shape, evenly distributed throughout the mass, with single pieces of paprika and coriander seeds |
| Taste and smell                         | Moderate cheese, brackish taste with mutually complement delicate aftertaste and aroma of coriander seeds and paprika |
| Brine quality                           | Opaque, slightly unclear                                                                             |

Table 2 shows that the nutritional value of the developed cheese product was sufficiently higher than the value of the control sample. The product was well protein/fat balanced; dietary fiber developed and made 28% of the recommended norm [8]. The sensory characteristics were high, the product acquired pleasant, moderately pronounced cheese brackish taste with a mutually complement delicate aftertaste and aroma of coriander seeds and paprika; the cross-sectional pattern had round and oval eyes with single pieces of reddish paprika and coriander seeds uniformly distributed throughout the mass of the cheese.

The study of safety indicators found no antibiotics in the Donskaya domiati cheese; the content of toxic elements, pesticides, radionuclides, and mycotoxins did not exceed the values regulated by TR CU 033/2013 “On the safety of milk and dairy products”.

The analysis of the table showed that the vitamin and mineral compositions of “Donskaya” domiati cheese changed due to plant ingredients, i.e., potassium and iron increased by 30.0%, magnesium by14.3%, phosphorus by 1.5%, and calcium by 0.9%. There was found valuable trace element selenium and vitamins (K, B3, B4, and α-carotene); the content of β-carotene increased 5 times, vitamin E 2 times, vitamin B6 by 28.6%, vitamin A by 13, 7%, and vitamin B5 by 10.0%, which led to an increase in biological value of the product. Iron takes part in the blood circulation mechanism, affects the general condition of skin, and improves the endocrine system and immunity. Vitamin B6 is involved in protein metabolism and formation of hemoglobin. The fat-soluble vitamin A regulates vision, ensures the adaptation of the eye to darkness, enhances visual acuity, and expands the field of color vision.
Thus, an increase in the content of vitamins 1.7 times and minerals 2.5 times in an innovative product was due to plant components that enhanced the biological value and made the product functional.

Based on the results obtained, there was developed technical documentation, i.e., STO 9229-029-00493468-18 “Donskaya domiati cheese product enriched with plant components” and technological instructions. The developed technology implemented to the dairy industry will expand the range of cheese products for proper nutrition of the population.

Table 3. Vitamin and mineral compositions of “Donskaya” domiati cheese.

| Name            | Control   | Prototype  |
|-----------------|-----------|------------|
| **Mineral composition** |           |            |
| Calcium, mg     | 630.0±0.003 | 635.84±0.003 |
| Potassium, mg   | 95.0±0.002  | 124.14±0.003 |
| Magnesium, mg   | 24.0±0.002  | 27.43±0.002  |
| Phosphorus, mg  | 210.0±0.003 | 213.14±0.003 |
| Sodium, mg      | 1200.0±0.003 | 1200.78±0.003 |
| Iron, mg        | 0.7±0.002   | 0.91±0.002   |
| Zinc, mg        | 3.7±0.002   | 3.74±0.002   |
| Sulfur, mg      | 221.0±0.003 | 221.62±0.003 |
| Selenium, mcg   | not found   | 0.06±0.002   |
| **Vitamin composition** |           |            |
| Vitamin A, mcg  | 180.0±0.003 | 204.63±0.002 |
| β-carotene, mcg | 60.0±0.002  | 321.62±0.002 |
| α-carotene, mcg | not found   | 5.95±0.002   |
| Vitamin E, mg   | 0.3±0.002   | 0.59±0.002   |
| Vitamin K, mcg  | not found   | 0.80±0.002   |
| Vitamin C, mg   | 1.0±0.002   | 1.01±0.002   |
| Vitamin B1, mg  | 0.04±0.002  | 0.043±0.002  |
| Vitamin B2, mg  | 0.12±0.002  | 0.13±0.002   |
| Vitamin B3, mg  | not found   | 0.10±0.002   |
| Vitamin B4, mg  | not found   | 0.52±0.002   |
| Vitamin B5, mg  | 0.3±0.002   | 0.33±0.002   |
| Vitamin B6, mg  | 0.07±0.002  | 0.09±0.002   |
| Vitamin B9, mcg | 21.0±0.002  | 21.49±0.002  |

4. Conclusion
The studies determined the compositions and properties of coriander, paprika, and β-carotene and found them to be rich in vitamins, macro- and microelements, dietary fiber, essential amino, and fatty acids and to have health-promoting properties. They contribute to increasing nutritional and biological value, so they are advisable to use as fortifiers cheese production, which will. The doses, the preparation procedure, and the technological point of introducing plant ingredients were established; the most suitable probiotic complex, necessary for the cheese production, was selected. Based on the results obtained, a cheese product technology and a set of technical documentation STO 9229-029-00493468-18 “Donskaya domiati cheese product enriched with plant components” were developed, and its quality was assessed. The nutritional and energy value of the developed cheese product was established to be higher than that of the control sample. The product was well protein/fat balanced, dietary fiber appeared, and made 28% of the recommended norm. The sensory characteristics were high; the product acquired pleasant, moderately pronounced cheese, brackish taste with a mutually complement delicate aftertaste and aroma of coriander seeds and paprika; the cross-sectional pattern had round and oval eyes; single pieces of reddish paprika and coriander seeds were uniformly distributed throughout mass of the cheese. Due to the plant ingredients, the vitamin and mineral compositions of the “Donskaya” domiati cheese product changed; there was an increase in minerals 2.5 times (potassium, iron, magnesium, and
phosphorus) and vitamins by 70.0% (β-carotene, vitamin A, E, B6, B5); the trace element selenium and vitamins K, B3, B4, and α-carotene appeared, which led to an increase in the biological value of the cheese product.

Thus, the developed enriched “Donskaya” domiati cheese product had high consumer properties, high nutritional and biological values and was safe for consumers. The beneficial properties of the innovative product can become a basis for the promotion strategy for the functional cheese product in the market among competing brands.

References
[1] Santiago-López L, Aguilar-Toalá J E, Hernández-Mendoza A, Vallejo-Cordoba B, Liceaga A M and González-Córdova A F 2018 Invited review: Bioactive compounds produced during cheese ripening and health effects associated with aged cheese consumption. J Dairy Sci. 101(5) 3742-57
[2] Nicklaus S, Divaret-Chauveau A, Chardon M L et al. 2019 The protective effect of cheese consumption at 18 months on allergic diseases in the first 6 years. Allergy. 74(4) 788-98
[3] Slozhenkina M I, Gorlov I F, Kryuchkova V V, Serkova A D and Belik S N 2019 Vegetable ingredient in cheese product Potravinarstvo Slovak Journal of Food Sciences 1(13) 1018-25
[4] Silva F and Domingues F C 2017 Antimicrobial activity of coriander oil and its effectiveness as food preservative Crit Rev Food Sci Nutr. 57(1) 35-47
[5] Sahib N G, Anwar F, Gilani A H, Hamid A A, Saari N and Alkharfy K M 2013 Coriander (Coriandrum sativum L.): a potential source of high-value components for functional foods and nutraceuticals-a review Phytother Res 27(10) 1439-56
[6] Kryuchkova V V, Drucker O V and Skripin P V 2017 Sour-milk product enriched with phyto-components and lactulose syrup Dairy industry 2 59-60
[7] Dhyani N, Parveen A, Siddiqi A, Hussain M E and Fahim M 2018 Cardioprotective Efficacy of Coriandrum sativum (L.) Seed Extract in Heart Failure Rats Through Modulation of Endothelin Receptors and Antioxidant Potential J Diet Suppl. 9 1-14
[8] Shukla S, Kumar D A, Anusha S V and Tiwari A K 2016 Antihyperglucolipidaemic and anticarbonyl stress properties in green, yellow and red sweet bell peppers (Capsicum annuum L.) Nat Prod Res. 30(5) 583-9
[9] Yazdizadeh Shotorbani N, Jamei R and Heidari R 2013 Antioxidant activities of two sweet pepper Capsicum annuum L. varieties phenolic extracts and the effects of thermal treatment Avicenna J Phytomed 3(1) 25-34
[10] Sanati S, Razavi B M and Hosseinzadeh H 2018 A review of the effects of Capsicum annuum L. and its constituent, capsaicin, in metabolic syndrome Iran J Basic Med Sci 21(5) 439-48
[11] Matos A, Gonçalves VMDS, Souza G, Cruz SP D, Cruz S and Ramalho A 2018 Vitamin A nutritional status in patients with coronary artery disease and its correlation with the severity of the disease Nutr Hosp 35(5) 1215-20
[12] Cordeiro A, Bento C, Matos A C and Ramalho A 2018 Vitamin A deficiency is associated with body mass index and body adiposity in women with recommended intake of vitamin A. Nutr Hosp 35(5) 1072-78