Brine-ripened cheese for prevention of selenium deficiency

N I Mosolova¹, I F Gorlov¹,², M I Slozhenkina¹,², S E Bozhkova²,³, D S Belova², O Yu Mishina¹ and S A Brekhova¹

¹ Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production, 6, Rokossovskogo street, Volgograd, 400131, Russian Federation
² Volgograd State Technical University, 28, V.I. Lenin Ave., Volgograd, 400005, Russian Federation
³ E-mail: bozhkova@mail.ru

Abstract. Due to the nutritional deficiency being ubiquitous, the need to develop and manufacture food fortified is greater than ever. The purpose of the work was to develop a recipe for a fortified product and produce and analyze it. Brine-ripened suluguni cheese was taken as the basis of the product and milk thistle (Silybum) and flax seeds in one sample and walnut kernels and milk thistle seeds in the other one were investigated as fillers. The study has revealed an increase in the nutritional and biological value of Test samples in comparison with Control one due to the selected plant components, i.e. a decrease in the weight fraction of moisture and an increase in the weight fractions of fat and protein. The developed products were rich in selenium, which allowed them to be recommended for people suffering from selenium deficiency.

1. Introduction
Today, the problem of starvation and malnutrition in all its forms is more acute than ever. According to the data in the latest edition of The State of Food Security and Nutrition in the World 2020, billions of people cannot afford balanced foods due to their low affordability [1, 2]. Consequently, the solution to the problem of an unbalanced diet of the population, first of all, involves reducing the cost of food products and their enrichment with regional plant raw materials. Partial replacement of the main raw material of animal origin with vegetable ingredients will not only reduce the cost of the final product, but also increase its yield and allow the finished product to be enriched with vitamins, macro- and microelements that the replaced material contains in small quantities or does not contain at all.

Brine-ripened cheese contains a huge amount of macro- and microelements, essential amino acids, and vitamins. The cheese regularly consumed has a beneficial effect on the metabolism, improves hair and nails health, normalizes the functioning of the digestive system, strengthens bones, and positively affects heart and blood vessels. Brine-ripened cheese was proposed to be fortified with macro-microelements, vitamins, amino and fatty acids, and fiber due to milk thistle seeds and walnut kernels that are rich in Mn, Se, Cu, Mg, Fe, and Zn, their lack in the body leads to a decrease in general immunity, problems with concentration, loss of vision, growth retardation in children, diseases of the gastrointestinal tract, etc. [3-8].

This study was aimed at solving the problem of selenium deficiency in the human body due to functional food, in particular, cheese products. The relevance of the work lies in the development of...
selenium-enriched cheese products that are unique on the Russian cheese market and their manufacturing.

The novelty of the research lies in improving the consumer properties of cheese products by increasing the selenium content as well as expanding the range of cheese products.

2. Purpose and objectives
The purpose of the study was to develop a recipe for cheese enriched with milk thistle seeds, flax seeds, and walnut kernels, as well as analyze the composition and properties of the product obtained. The research objectives were to analyze sensory properties, physical and chemical indicators, nutritional value of the product, and selenium content.

3. Methods and materials
The research block diagram is shown in figure 1.

![Figure 1. The research block diagram.](image)

The objects of the research were raw cow milk and a product made from the raw milk according to the generally accepted technology for suluguni-type brine-ripened cheese. We developed three
cheese samples, namely, Test sample I—cheese roll with milk thistle and flax seeds, Test sample II—cheese roll with milk thistle seeds and walnut kernels, and Control sample—filler-free cheese roll that were subjected to sensory and physicochemical analyses in the laboratory of the Department of Food Production Technology at the Volgograd State Technical University and in the integrated analytical laboratory of the State Scientific Institution NIIMMP in accordance with generally accepted procedures.

The parameters of raw cow milk were found by the following methods: sensory properties were determined according to the generally accepted 5-point procedure, the weight fraction of protein was determined by the Kjeldahl method, the weight fraction of fat by the acid-butyrometric method, the acidity by the potentiometric method, the density by the hydrometric method, the purity groups using needle-punched canvas filters thermally bonded, and the ability of raw milk to coagulate under the influence of rennet and raw milk microorganisms was assessed according to the rennet-fermentation sample.

The physicochemical properties of the cheese roll samples were studied according to the generally accepted methods, i.e. the Kjeldahl method to determine the weight fraction of the protein content, the acid method to determine the weight fraction of the fat content, the Chizhova’s device to measure moisture, and the potentiometric method to find the pH.

The generated product samples were examined for the selenium content using a TA-Lab voltammetric analyzer.

4. Results and discussion

4.1. Analysis of the raw milk quality

The product was based on suluguni cheese—a semi-hard, drawn, brine-ripened cheese made from pre-normalized pasteurized cow’s milk using the traditional acid-rennet method. The quality indicators of the raw milk are shown in Table 1.

| Indicator                      | Normal Value          | Value for the studied cow’s milk       |
|--------------------------------|-----------------------|----------------------------------------|
| Appearance and consistency     | homogeneous liquid    | homogeneous liquid without sediment and flakes |
| Taste and smell                | clean, without foreign tastes and odors | clean, without foreign tastes and odors |
| Colour                         | from white to faint yellow | white                                   |
| Weight fraction of protein, %  | 2.8                   | 2.8                                    |
| Weight fraction of fat, %      | 3.1                   | 3.3                                    |
| Acidity, °T                    | 16.0-18.0             | 17.5                                   |
| Density, kg/m³                 | 1027.0                | 1027.0                                 |
| Cleanliness group              | I                     | I                                      |
| Rennet-fermentation sample, class, not lower | I, II | I |

As a result of the scientific and economic experiments, the raw milk obtained from cows of Australian selection fully met the requirements for the cheese production [9, 10, 11].

4.2. Recipe optimization and production method development

The production of a suluguni-based cheese roll had several features, i.e. the ripening temperature of 36-37 °C, coagulation time of 1-1.5 h, and simultaneous salting and melting by immersing the cheese into brine with a salt concentration of 12-16% and a temperature of 76-80 °C. Then the cheese dough was rolled out into a layer, dried, added with a pre-prepared filler—fried walnut kernels and flax seeds
in Test sample I and fried and crushed milk thistle seeds in Test sample II. Finally, the cheese layer was rolled up and added with crushed seeds and kernels.

The prospect of milk thistle seeds and walnut kernels used in the recipe for the cheese roll was determined by the chemical composition of the plant ingredients. The main advantage is their special mineral composition and hygroscopicity. Milk thistle seeds and walnut kernels contain large amounts of Mn, Se, Cu, Mg, Fe, and Zn.

In total, 3 samples were developed, namely, Control sample, Test sample I with milk thistle and flax seeds, and Test sample II with walnut kernels and milk thistle seeds. The samples were subsequently subjected to the sensory analysis. Its results are presented in the form of a profilogram (figure 1).

![Figure 2. Profilogram of organoleptic indicators prototypes: 1-unsatisfactory; 2-satisfactory; 3-good; 4-very good; 5-excellent.](image)

The sensory parameters of Test samples I and II were improved in comparison with Control sample, because they acquired an appetite-inducing aroma due to the plant components added into the formulation, while the taste and aroma in Control sample were insufficiently expressed. Sensory characteristics of the samples under study are described in table 2 in more detail.

**Table 2. Sensory characteristics of samples.**

| Indicator          | Characteristic Control | Test                                                                 |
|--------------------|------------------------|----------------------------------------------------------------------|
| Appearance         | there is no crust, the consistency is layered, elastic             | there is no crust, the surface is smooth, without traces of filler; the consistency is uniform, moderately dense |
| Sectional view     | –                      | coiled, non-crumbling cheese layer, evenly layered with a mixture of filler |
| Taste and smell    | weakly expressed cheese, pure, fermented milk, moderately salty    | pure, slightly salted, fermented milk, with a pronounced taste and a faint nutty smell |
| Drawing            | the drawing is missing                                          | the drawing is missing                                               |
| Colour             | the surface is uniform, white                                    | the surface is uniform, white                                         |
4.3. Analysis of physicochemical parameters of experimental samples

The results of the physicochemical analysis of parameters are presented in table 3. Physicochemical analysis revealed that in Test sample I, the weight fraction of moisture decreased by 2.3% and the weight fractions of protein and fat increased by 0.4% and 2.2%, respectively, compared to Control sample. In Test sample II, the weight fraction of moisture decreased by 1.5% and the weight fractions of protein and fat increased by 0.2% and 1.4%, respectively, which significantly increased the nutritional value of the product. Since the cheeses were produced using the same technology, their pH was equal.

| Indicator                        | Actual value | Control   | Test I     | Test II    |
|----------------------------------|--------------|-----------|------------|------------|
| Weight fraction of protein, %    | 17.9±0.01    | 18.3±0.01 | 18.1±0.01  |            |
| Weight fraction of fat in terms of dry matter, % | 45.3±0.02 | 47.5±0.05 | 46.5±0.05  |            |
| Weight fraction of moisture, %   | 52.0±0.06    | 49.7±0.04 | 50.5±0.04  |            |
| pH                               | 4.7±0.01     | 4.7±0.01  | 4.7±0.01   |            |

4.4 Analysis of selenium content in experimental samples

In accordance with the purpose of the research to develop products for the prevention of selenium deficiency, taking into account the fact that the used plant raw material is a rich source of the microelement Se, a comparative analysis of the selenium content in Control and Test samples was carried out. Its results are shown in figure 3.

The analysis showed that the systematic consumption of the developed cheese product in the amount of the recommended daily allowance for cheese (17 g/day), the physiological need was replenished for 22%, with the average physiological need for selenium being of 55 μg per day, which allowed the developed product to be classified as a functional product and recommend for the prevention of selenium deficiency.

5. Conclusions

Thus, the performed investigation proved the practicability of milk thistle seeds and walnut kernels, as well as milk thistle and flax seeds being used as plant fillers.

According to the results of the analysis, the vegetable fillers in the cheese roll had a positive effect on the consumer properties of cheese products and contributed to an increase in their nutritional value. The seeds added into the recipe were also revealed to increase the weight fractions of protein and fat of the product, as well as reduce the weight fraction of moisture, which had a beneficial effect on the quality indicators of the finished products.
The analysis also showed that the selenium content in the product (when consumed in the recommended daily requirement) corresponded to the physiological need for this trace element for at least 20%.

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