

An Advanced Biotechnological Trend—Production of Soft Cheeses Based on Milk of Various Types of Farm Animals in the Altai Region

Natalya Gavrilova
Department of Food and Food Biotechnology
Omsk State Agrarian University
named after P.A. Stolypin
Omsk, Russia
ORCID: 0000-0001-8544-4214

Elena Schetinina
Department of Food Technology
Altai State Technical University
named after I.I. Polzunova
Barnaul, Russia
ORCID 0000-0002-3463-9502

Abstract—The purpose of this scientific and practical work is to conduct research on the chemical composition and quality indicators of cow's, goat's and sheep's milk in the Altai Region and determine the prospects for their use in order to expand the soft cheese production. Statistical data for 2017-2018 indicate the actual dynamics of development of goat and sheep breeding, both in the Altai Region and in Russia as a whole. A study of the chemical composition and physical-chemical parameters makes it possible to note that goat's and sheep's milk has a high mass fraction of fat. Sheep's milk is rich in protein, and goat's milk proteins contain a high amount of essential amino acids that are hypoallergenic and biologically complete. The study of the coagulation process of milk of farm animals by the acid-rennet method allows us to consider its cheese-suitability and recommend it for the production of soft cheese enriched with functional ingredients based on local plant materials.

Keywords—animal milk, soft cheese, goat breeding, sheep breeding, acid-rennet method.

I. INTRODUCTION

The problem of proper, healthy nutrition in modern condition is becoming more and more urgent every year. As I.I. Mechnikov believed, people prematurely age and die due to malnutrition, while a person eating natural foods can live up to 130-150 years [1].

The consumers' interest in traditional products, including dairy, is relevant. The popularity of cheese is growing dynamically: it is now actively recommended by nutritionists as a product rich in calcium, milk fat and there is almost no carbohydrate – the lactose [2].

Expansion of the assortment of soft non-ripening and quick-ripening cheeses is challenging and is characterized by:

- convenient packaging;
- functional properties;
- new flavoring touches;
- low calorie content;
- balanced fat phase;
- high protein content and other factors.

Cheeses are of high nutritional and biological value, have a big variety of tastes; as a result they are in demand in the nutrition of population of all age groups. Modern specialized literature, professional scientific and practical journals and patent information, both Russian and foreign,

clearly trace the development trends of traditional and the creation of innovative cheese technologies [3-4].

A.Yu. Prosekov characterizing the state and prospects for the development of cheese production in Russia notes that in 2010-2017 cheese production increased by 19%, while the regional structure remained traditional – the first place, 14% of Russian production, belongs to the Altai Region [5].

The production of soft cheeses is dynamically developing, which is caused by the technological features of their production, the increased content of the mass fraction of moisture, lower consumption of raw milk and, of course, the diversity of their type features, organoleptic characteristics, as well as other factors.

I.A. Smirnova, S.V. Gutova proposed to use wheat germ flakes in an amount of 0,5-1,5% by weight of the mixture in the production of soft cheese without ripening [6].

N.B. Gavrilova developed method for the production of soft cheese enriched with whey proteins and a bio-enrichment agent, fermented with bacterial ferment of probiotic cultures [7].

I.R. Zaripov conducted research and developed soft cheese technology with a long shelf life of 30 days at a temperature of $(4 \pm 2) ^\circ\text{C}$. Cheese is enriched with essential amino acids. For the implementation of the "Kurultay" soft cheese technology, the regulatory documentation TU 9225-001-05250492-2007 has been developed [8].

E.M. Shchetinina provides statistics on the prospects for the growth and development of goat breeding in the Altai Region, and also describes various options for processing goat's and sheep's milk into functional food products [9-10].

I.M. Mironenko, points out the thermo-acid coagulation, on the basis of a comparative analysis of various types of milk coagulation, considering the features of production and the assortment of thermo-acid cheeses produced in foreign countries. He also reports on the development of two technologies of thermo-acid cheeses: "Phoenix" cheese (TU 9225-063-00419710-13) from whole reconstituted milk and "Znat" cheese (TU 9225-065-00419710-13) from natural milk. Their main distinguishing feature is the use of glucono delta-lactone (GDL) as an acidifier [11].

Scientists of the Federal Altai Scientific Center for Agrobiotechnology have developed a technology for a new type of soft cheese, "Globosum", which is distinguished by its creamy taste and the content of probiotic microflora [12].

Scientists at the All-Russian Research Institute of Butter-making and Cheese-making are systematically working on improving traditional technologies using new processing methods (including ultrafiltration) and developing new economically viable soft cheese technologies [13].

G.M. Sviridenko gives data from analytical and experimental studies on bacterial concentrates, the number of viable cells that they must contain in order to ensure the production of fermented products and, above all, cheese [14].

As experts and scientists note, bacterial starter cultures (concentrates) in any form can be conditionally divided into technologically necessary starter microflora, which provides specific and organoleptic characteristics of cheese, as well as special starter that gives the probiotic properties in cheese.

N.P. Sorokina recommends for use an assortment of mono-specific and poly-special concentrates for special purposes, which inhibit the development of acid bacteria, accelerate the maturation of cheese [15].

Yu.Ya. Sviridenko et al. note that the creation of technologies for functional cheeses and cheese products, which are enriched with physiologically useful food ingredients that improve human health, is relevant in the recent years. For the production of these cheeses, "Bifilact-U" special bacterial concentrates for "Slavyanskiy" cheese and "Bifilact-D" for "Aibolit" cheese have been developed. The composition of the concentrates includes bifidobacteria, thermophilic streptococci, lactococci (*L. lactis*, *L. cremoris*, *L. diacetylactis*), which are in symbiotic interaction. Dry bacterial concentrates contain more than 100 billion CFU/g. In the finished product, the content of bifidobacteria is 107-109 CFU/g [16].

The main raw material for the production of cheeses: hard, semi-hard, soft is the milk – the product of the lactating animals' secretion: cows, goats, buffaloes, sheep, mares, etc. However, in Russia, cheeses are produced mainly from cow's milk.

Considering the above, experts in the Altai Region, the center of Russian cheese production, carried out a technical-economic study in order to plan the assortment policy of cheese making enterprises [17].

Based on the studies of the cheese-making market and our own assortment, the following recommendations are given – to introduce soft types of cheeses into production, which will increase the coefficient of the assortment completeness; increase profitability and cover the customers' demand in the cheeses of this type.

An important problem of increasing the assortment and volume of production of soft cheese is the raw material base. Despite the fact that milk producers of the Altai Region are in third place in Russia in its volumes, nevertheless, the effectiveness of the cheese-making enterprises also depends on the quality, safety and cheese suitability of milk [18-19].

A certain raw material reserve for cheese making is milk of goats and sheep.

Every year in Russia, goat and sheep breeding are developing more and more intensively, in connection with which the objective of this research project is to determine the prospects of its use for expanding the soft cheese assortment on the basis of a study of chemical composition and qualitative indicators of cheeses from cow's, goat's and sheep's milk in the Altai Region.

II. METHODS

As objects of research were used:

- raw cow's milk according to GOST 31449-2013;
- raw goat's milk in accordance with GOST 32940-2014;
- sheep's milk [9];
- enzyme preparation "Kalase 150" (production of CSK Food Enrichment, Netherlands);
- bacterial concentrate of mesophilic streptococci of direct application of BK-Altai-S [20,21].

Studies were conducted in 2017-2018 on the livestock of the Altai Region's farm animals: milk of Simmental cows, milk of goats of the Saanen breed, milk of sheep of the Kulunda breed.

Modern methods and devices are used for determination of chemical indicators of products. The repetition of experiments is 5-fold. The results were processed using methods of mathematical statistics using standard software packages "Math CAD - 14 Professional".

III. RESULTS AND DISCUSSION

Among modern vectors for the development of the Russian dairy industry, goat breeding is significant, which corresponds to global trends in the state and dynamics of the goat population and goat milk production [22]. Sheep breeding is also a popular area in animal husbandry [23]. In Europe, goat and sheep milk for many centuries occupies one of the leading positions, both in the production of drinking milk and as raw materials for the production of a wide range of cheeses. Moreover, cheeses are produced not only from one type of raw material, but also their various compositions. In the Altai Region, both goat breeding and sheep breeding with the processing of milk for dairy products in agricultural enterprises and farms, are developing dynamically. The Altai Region is the center of cheese production, however, cheeses are mainly made from cow's milk, and goat's and sheep's milk is of interest for the production of fermented dairy products, including soft cheese. The main results of determining the chemical composition and physical-chemical parameters of cow's, sheep's and goat's milk are shown in table I.

TABLE I. CHEMICAL COMPOSITION, PHYSICAL AND CHEMICAL INDICES OF MILK OF DIFFERENT TYPES OF AGRICULTURAL ANIMALS IN ALTAI REGION

Indicator	Actual value			Regulation document on analysis method
	Cow's milk	Goat's milk	Sheep's milk	
Mass fraction of fat, %	3,80±0,10	4,30±0,10	4,15±0,10	GOST 5867-90
Mass fraction of total protein, %	3,30±0,11	2,94±0,12	5,31±0,10	GOST 23327-98
Mass fraction of lactose, %	4,50±0,11	4,35±0,10	4,80±0,05	GOST 54667-11
Acidity, °T	19,0±0,5	19,3±0,3	19,5±0,5	GOST 3624-92
Density, kg/m ³	1027,5±0,5	1027,0±0,5	1028,0±0,5	GOST 3625-84

An analysis of the experimental data presented in Table I allows us to see that goat's and sheep's milk have a higher fat content compared to cow's. Sheep's milk is rich in protein – its average amount is at 5.31%, while according to GOST 32940-2014 in cow's milk should be at least 2.8%, and in experimental samples of fat there was actually (3,30 ± 0,11)% . Goat milk proteins, despite the fact that their mass fraction at (2,94 ± 0,11)%, contain a high amount of essential amino acids that are hypoallergenic and biologically complete in terms of nutritional physiology [10].

Analysis of the organoleptic characteristics of samples of cow's, goat's and sheep's milk showed that they all comply with regulatory requirements for raw milk. It should be noted that sheep's milk has a sweetish taste and a yellow tint due to its higher fat content.

There is a specific smell and taste of goat milk, its severity depends on the conditions of animals in the farms, as well as the presence of males in close proximity to the females.

The results of the study of the quantitative content of vitamins in experimental samples of cow's, goat's and sheep's milk are shown in table II.

TABLE II. CHARACTERISTIC OF VITAMIN COMPOSITION OF MILK OF VARIOUS SPECIES OF AGRICULTURAL ANIMALS IN ALTAI REGION

Vitamin composition of milk	Cow's milk	Goat's milk	Sheep's milk
A, mg/100 g	0,08	0,20	0,44
C, mg/100 g	1,12	1,44	4,20
B ₁ , mg/100 g	0,10	0,10	0,10
B ₂ , mg/100 g	0,27	0,05	0,40
B ₃ , mg/100 g	0,02	0,03	0,40
B ₉ , mg/100 g	0,04	0,02	0,07

Analysis of the data presented in table II allows us to note that sheep's milk is rich in vitamins; their amount slightly exceeds the mass fraction of vitamins in cow's and goat's milk.

As for the mineral composition, there was a sufficient content of calcium and phosphorus in all milk samples, which are necessary for the production of cheese; so the actual amount of calcium in cow's milk is (124 ± 10) mg%, phosphorus (97 ± 5) mg%; in goat's milk – calcium (118 ± 15) mg%, phosphorus (96 ± 3) mg%; in sheep's milk – calcium (193 ± 2) mg%, phosphorus (155,6 ± 1,5) mg%.

An important characteristic of the cheese-suitability of milk is its rennet coagulation. The acid-rennet method of milk coagulation was used for the study, then the milk was pasteurized at a temperature of (74,0 ± 1,0)°C with an

exposure of 15-20 s, cooled down to a coagulation temperature (34 ± 2) °C, then calcium chloride was introduced in an amount of 200 g per 100 kg of milk in the form of a 40% aqueous solution, BK-Altai-S sourdough was added at the standard rate. For the clotting of the fermented mixture, the Kalase 150 liquid enzyme preparation with an activity of 150 IMCU/ml was used. Coagulation time was:

- for cow's milk (35 ± 2) min;
- for goat's milk (32 ± 2) min;
- for sheep's milk (40 ± 2) min.

Characterizing the quality of the clots, it should be noted that the clot obtained by coagulation of goat milk was dense, but not stable, which caused a loss of protein in whey due to the formation of a large amount of cheese dust. The dynamics of active acidity of experimental soft cheeses in the process of their preparation and processing is presented in Fig. 1.

The clots were processed, that is, cut into cubes with a rib size of 5 cm, the exposure time was 4-10 minutes, then cut into cubes with a rib size of 2-3 cm and the cheese mass was mixed with a gradual separation of the whey to 60%.

The next step in the production of soft cheese was molding. Cheese was distributed in special forms in order to obtain cheese wheels with weight of (195 ± 5) g.

Then the cheese was subjected to self-pressing, brining (salting) and drying.

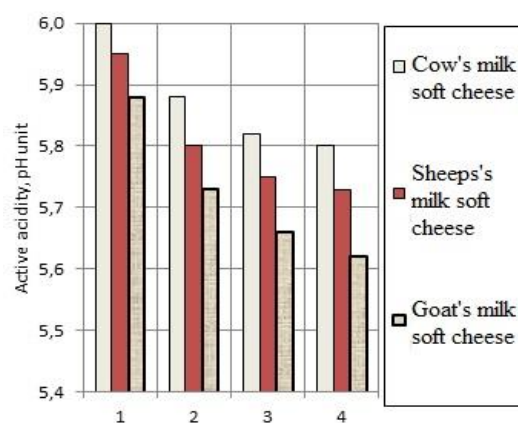


Fig. 1. Dynamics of active acidity during cheese processing: 1 - after processing the clot; 2 - after molding and self-pressing; 3 - after brining; 4 - after drying.

Organoleptic characteristics of soft cheese from milk of various types of farm animals are presented in table III.

TABLE III. ORGANOLEPTIC INDICATORS OF SOFT CHEESE OBTAINED FROM MILK OF DIFFERENT TYPES OF AGRICULTURAL ANIMALS IN ALTAI REGION

Soft cheeses	Taste and smell	Texture	Appearance
Cow's milk soft cheese	Of pure fermented milk	Creamy, uniform	Flat surface, with cheesecloth markings
Goat's milk soft cheese	Pure sour milk with light smell and a touch of goat's milk	Creamy, uniform	Flat surface, with cheesecloth markings
Sheep's milk soft cheese	Pure sour milk with light smell and a touch of sheep's milk	Uniform, somewhat dense	Flat surface, with cheesecloth markings

IV. CONCLUSION

Literature and statistics analysis allows us to consider the assortment range and production volumes of soft cheese using milk of various types of farm animals expanding as a relevant issue.

Experimental studies of the chemical composition and physical-chemical parameters of milk of various types of farm animals in the Altai Region made it possible to consider goat's and sheep's milk as biologically complete and cheese-suitable for use in soft cheese biotechnology.

It is recommended to expand the assortment range of soft cheeses production in the Altai Region using goat's and sheep's milk, as well as to develop formulations with the addition of components based on local plant raw materials for enriching cheeses and leveling the specific smell and taste of goat's and sheep's milk.

REFERENCES

- [1] L.B. Dzantieva, V.B. Tsugkieva, R.B. Albegov, B.G. Tsugkiev and A.A. Abaev, "Use of inulin-containing plant materials for the production of healthy food," *Pishchevaya promyshlennost* (Food industry), No. 6, pp. 10-13, 2019. (in russ.)
- [2] Yu. Kelyashova, "Low-fat cheeses: an actual trend of the Russian market," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 2, pp. 36-37, 2016. (in russ.)
- [3] V.Ya. Lyakh, I.A. Shergina and T.N. Gardening, *Reference cheesemaker*. Saint Petersburg: Profession, 2011.
- [4] P.L.G. McSweeney, *Practical recommendations for cheese makers*. Saint Petersburg: Profession, 2010.
- [5] A.Yu. Prosekov, "Russia on the world cheese market: prospects of development," *Syrodellie i maslodellie* (Cheese making and oil-making), No. 6, pp. 4-6, 2018. (in russ.)
- [6] I.A. Smirnova and S.V. Gutova, Patent Russian Federation No. 2210923 A23C 19/076 "Maturation-free method of producing soft cheese with the use of wheat germ flakes," Publ. 27.08.2003.
- [7] N.B. Gavrilova, O.N. Podkorytov and T.V. Rybchenko, Patent Russian Federation No. 2535994 A23C 19/076 "Soft cheese production method," Publ. 20.12.2014.
- [8] I.R. Zaripov, N.B. Gavrilova and O.V. Pasko, Patent Russian Federation No. 2313947 A23C 19/076 "Method for producing of soft cheese," Publ. 10.01.2008.
- [9] E.M. Shchetinina, "Prospects of sheep milk processing in the Altai Territory," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 2, pp. 19-21, 2018. (in russ.)
- [10] N.B. Gavrilova and E.M. Bristles, "Goat's Milk - Biologically Full-Grade Raw Materials for Specialized Food Products," *Hranenie i pererabotka selhozsyraya* (Storage and processing of farm products), No. 1, pp. 66-75, 2019. (in russ.)
- [11] I.M. Mironenko, "Special issues of producing thermo-acid cheeses," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 3, pp. 52-54, 2014 (in russ.)
- [12] I.A. Funk, R.V. Dorofeev and E.F. Ott, "Soft cheese "Globozum," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 6, pp. 24-25, 2017. (in russ.)
- [13] V.A. Mordvinova and D.V. Ostroukhov, "Soft cheese from the UF-concentrate of milk," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 2, pp. 20-21, 2014. (in russ.)
- [14] G.M. Sviridenko, "Bacterial concentrates: ways to apply in the fermented milk products manufacturing," *Molochnaya promyshlennost* (Dairy industry), No. 6, pp. 25-28, 2015. (in russ.)
- [15] N.P. Sorokina, E.V. Kuraeva and I.V. Kucherenko, "Bacterial starters for cheese production," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 4, pp. 26-31, 2016. (in russ.)
- [16] Yu.Ya. Sviridenko, I.A. Shergina and O.V. Lepilkina, "Cheese and cheese products with functional purposes," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 2, pp. 18-19, 2007. (in russ.)
- [17] A.V. Krieger and Yu.G. Sturova, "Formation of the varieties policy at a cheese plant in the context of embargo," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 4, pp. 17-21, 2016. (in russ.)
- [18] N.B. Gavrilova and E.M. Shchetinina, "Prospects of the specialized food products manufacturing using milk of the goats of the Altai region," *Molochnaya promyshlennost* (Dairy industry), No. 6, pp. 56-57, 2019. (in russ.)
- [19] G.V. Murunova and T.E. Municheva, "About rennet properties of milk," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 4, pp. 49-50, 2016. (in russ.)
- [20] N.V. Bakhnova, "Bacterial concentrates and starters of the Biofactory Barnaulskaya," *Syrodellie i maslodellie* (Cheese-making and oil-making), No. 6, pp. 34-36, 2011. (in russ.)
- [21] "Functional products," *Trendler: Global technology trends*, No. 15., pp. 3, 2015.
- [22] A.I. Erokhin, E.A. Karasev and S.A. Erokhin, "The state and dynamics of the goat population and goat production in the world and in Russia," *Ovcy, kozy, sherstyanoe delo* (Sheep, goats, woolen work), No. 1, pp. 29-31, 2018. (in russ.)
- [23] G.A. Poghosyan and A.I. Erokhin, "The state and dynamics of sheep milk production in the world," *Ovcy, kozy, sherstyanoe delo* (Sheep, goats, woolen work), No. 1, pp. 34-35, 2013. (in russ.)