Biological usefulness of raw milk as a factor in obtaining high-quality cheeses

Irina Buyanova* *and Vladimir* Shrainer

Kemerovo State University, Kemerovo, st. Krasnaya, 6, Russian Federation

Abstract. Health saving is the main state program and a priority direction of scientific centers in Russia and Kuzbass. Cheese is a unique product representing a concentrate of milk fat and protein of high biological value. In cheesemaking, one of the key issues is the cheese suitability of milk. An analysis of the state of the issue made it possible to identify the purpose of scientific research: to study the technological aspects of obtaining raw milk and to establish ways to improve the properties for potential use in the cheese industry. To achieve this goal, the following tasks were solved: to study the features of the chemical composition, biological usefulness of raw milk in the conditions of the raw material base of the Tomsk region; highlight the main criteria that control the quality of cheeses, overcoming seasonality in obtaining raw materials. The results indicate a greater stability of casein in milk in spring and summer, which will affect the decrease in the rate of its coagulation during rennet coagulation. It was found that summer and winter milk was better in terms of technological properties than in other periods of the year. The properties of milk as a medium for the development of lactic acid bacteria change significantly over the seasons and depending on zootechnical factors. Trace elements are contained in the optimal ratio, and will promote the growth of lactic acid microorganisms of the starter, which will lead to a reduction in the ripening time of the cheese. Milk had high lactose values. It is shown that in the summer period lactose is slowly fermented during the ripening of cheeses and a significant amount of 0.23% lactic acid is formed. The content of citrates in milk was determined, which determine the rate of formation of carbon dioxide by aroma-forming microorganisms Lc. diacetylactis for cheese patterning.

1 Introduction

There are a number of problems in the dairy industry related to limited resources and seasonality in the production of raw milk, the high cost of manufactured products, which is reflected in the price. As a result, often higher quality domestic cheese products cannot compete with cheaper imports. As part of the import substitution program in Russia, the task of supporting and developing small businesses, and in particular the development of

* Corresponding author: ibuyanova_@mail.ru

small farms, has become urgent. For them, one of the significant tasks is to increase the yield of the product, which will make it possible to obtain a much greater profit, and the consumer will receive a quality product at significantly low prices [1, 2-5].

In accordance with modern ideas about rational nutrition, which has found expression in the formula of a balanced diet, cheeses are the most valuable products in nutritional and biological terms. Today, the production of cheese is very popular [4,5, 6]. They are included in the normal daily diet of various population groups [7, 8-11].

Each type of cheese is produced according to an individual technology, this is precisely the specificity of its organoleptic properties and quality indicators. Among the various types of cheeses, soft cheeses and semi-hard cheeses are one of the most popular, due to the delicate creamy taste of milk, the softness of the cheese dough. It contains a whole range of vitamins and microelements necessary for human health. The popularity of cheeses is due to the high biological value, good digestibility. First of all, a high content of easily digestible proteins, milk fat, calcium, essential amino acids and a wide range of trace elements, vitamins, combined with high taste [12, 13-18].

Many large milk processing enterprises, on the basis of agreements with agricultural producers, accept milk taking into account a number of additional indicators: the mass fraction of protein, the number of somatic cells, and thermal stability. Payment for raw milk accepted for processing can vary significantly depending on these indicators. Chilled, heat-resistant milk, as well as with a mass fraction of fat and protein above the basic norms, is paid with the current surcharges on the purchase price.

The quality of raw milk has been and remains one of the most pressing issues for the dairy industry. Fresh natural milk obtained from healthy animals is characterized by certain properties (organoleptic, physicochemical, microbiological), and must also meet the requirements of GOST and TR TS "Technical Regulations for Milk and Dairy Products" on biological safety. Thus, physical properties (freezing point, density, thermal stability, etc.) directly depend on the chemical composition of milk, in particular, on changes in the concentration of solids. The introduction of water into milk reduces the content of ions of water-soluble components of lactose and mineral salts, causing an increase in the freezing point (above minus 0.52 °C) and heat stability of milk [17, 18, 19].

Changing the constituents of raw milk and its properties undoubtedly affects the technological properties. The yield and quality of dairy products (cheese, butter, cottage cheese), determined by the composition of milk, the structure and properties of its components, are highly dependent on zootechnical factors.

In the industry, they solve the issues of increasing the biological value of raw milk, improving the technological properties, using scientific approaches. Increasing cheese suitability is important for solving the problem of seasonality in raw milk harvesting and creating conditions for organizing uniform cheese production throughout the year, and not just at the peak of “big” milk. Particular attention deserves the issues of bacterial contamination of milk, as well as sanitary and hygienic conditions for obtaining it from agricultural producers of various types of farms. The bacterial purity of milk is the key to obtaining high-quality cheese that is safe for consumption [20, 21-25,].

An analysis of the state of the issue made it possible to identify the purpose of scientific research: to study the technological aspects of obtaining raw milk and to establish ways to improve the physicochemical, microbiological properties, biological usefulness for the purpose of potential use in the cheese industry.

2 Objects and Methods of Investigation

To achieve this goal, the following tasks were set: to identify the main criteria that control the quality of cheeses, overcoming the seasonality in obtaining raw materials, on the basis of which recommendations were developed for industry enterprises on adjusting the properties of raw milk; to study the features of the chemical composition, biological usefulness of raw milk in the conditions of the raw material base of the Tomsk region and establish methods for effectively changing technological properties to increase the yield of semi-hard cheeses and reduce production losses.

The object of the study was whole cow's milk obtained in different periods of the year from three dairy farms in the conditions of the raw material base of the Yasinovsky district, Tomsk region. Reception of raw materials was carried out in accordance with the regulatory documentation TR CU 033/2013 "On the safety of milk and dairy products", TR CU 021/2011 "On food safety". Based on the initial stage of assessing the quality of milk, directions for further research in relation to cheese properties have been established. The main objective was to increase the yield and quality of cheese. Natural semi-hard rennet cheeses of the Gouda type were produced with a low temperature of the second heating. In research and development in the conditions of a cheese-making workshop, useful types of lactic acid bacteria were used in the form of bacterial preparations in liquid, dry form, as well as direct fermentation: BK-Uglich - 4, BK - Uglich-5A, Bioantibut, including strains of lactococcal cultures gas-forming microflora Lc. Diacetylactis; leuco-nostocas Leuc. mesenteroides subsp. Cremoris or Lactis., as well as mesophilic lactobacilli strain Lbc. Plantarum is an active antagonist of butyric acid bacteria.

For the study, standard, generally accepted methods of analysis were used.

3 Results and Discussion

It is known that the physiology of the animal, the conditions of keeping cows, the conditions for obtaining milk on farms determine a number of features in terms of the quality of milk. The rational use of zootechnical factors on farms, in private backyards gives good results in relation to the cheese properties of raw milk. It has been established that the environment, in particular sanitary conditions for obtaining milk, reduces the likelihood of possible coagulation of the protein fraction. In addition, after milking, the milk must be immediately cooled. In some farms, the inclusion of colostrum in the composition of raw combined milk (the norm is the delivery of milk after calving not earlier than the sixth day), the development of foreign bacteria and untimely cooling is manifested in an increase in acidity, which is not allowed for processing. In addition, other factors reduce the quality of harvested raw materials: the presence of herbicides in feed or disinfectant residues on dairy equipment, the addition of milk obtained from sick animals to prices [25, 26,27].

To determine the suitability of milk for processing, studies of technological properties were carried out during the year from various farms in terms of physical and chemical indicators. The results of the study are presented in table 1.

An analysis of the research results showed that the milk received for processing at a cheese factory meets the requirements of cheese making, although the milk of the spring-summer period should be more thoroughly cleaned of mechanical impurities and not subjected to high temperature heating regimes. In the autumn-winter period, the acidity of milk is somewhat overestimated, which is associated with a violation of the feeding rations, when the animals are kept in stalls and the diet includes mainly concentrated feed. All these zootechnical factors should be taken into account when developing technical regulations for the production of cheese [15,18, 21].

Table 1. Technological properties of cow's milk for cheese making from suppliers

Physicochemical characteristics	Milk producers		
	№ 1	№ 2	№ 3
Acidity. °T	16.5±0.2	16.8±0.2	17.0±0.2
Density. kg/m3	1028.5	1029.2	1027.5
Thermal stability. group	I	II	II
Fat content. %	3.8	4.1	4.3
Protein content. % including casein. % whey proteins. %	3.35 2.61 0.74	3.24 2.59 0.66	3.0 2.36 0.59
SOMO. %	8.53	8.63	8.87
Degree of purity according to the standard. group	I	I	I
The content of somatic cells. thousand/cm3	до 500	400	до 500
Bacterial contamination. class	1	1	1

As follows from Table. 1 Milk chemical composition differed for each supplier. Their fluctuations in fat were at the level of the general average annual value of 3.7 - 4.3 %. In the Autumn period, the fat content in milk was the highest. From the middle of winter to the middle of summer, the fat content of milk decreased. In summer, against the background of high milk yields, milk had a low fat content - 4.0% on average. The lowest fat content - 3.75% was recorded in June, the highest - 4.6% - in October.

According to the data of Table 1, the highest values of protein content (3.35%) were recorded in milk from supplier No. 1 and the lowest values (3.0%) in milk from supplier No. 3.

For cheese making, milk with a high content of casein and its fractions α, χ and β is most suitable. The ratio of fractions in a micelle can be different, but their sum is important. The results show their high content in the milk protein of the raw material base of the Tomsk region. The sum of fractions α, χ and β amounted to more than 91% over the periods of milk procurement. In the milk of the winter and especially the spring period, a pattern has been established for an increase in the γ-fraction. Table 2 shows the results of a study on the technological properties of milk in different periods of the year.

Table 2. Technological properties of raw milk by seasons

Period of the year	Clotting duration. min	Clot characteristic	Casein content. %	Fraction content β. α. χ- casein. % from the total	Casein particle size. nm
Winter	30.5	Dense. elastic	2.6	92.256	81.0
Spring	37	Loose. rennet lethargic	2.20	92.23	67.0
Summer	23.0	Dense. Elastic. well separating whey	2.76	92.46	65.3
Autumn	27.5	Strong. Dense. elastic. well separating whey	2.81	93.0	73.5

Table 2 shows that the particle size of casein is subject to large fluctuations over the periods of the year, which affects the stability of milk. So, the milk of the winter and

autumn periods is distinguished by the largest protein particles (81 nm), and the spring milk is the smallest (67 nm). Thus, milk proteins are more dispersed in spring and summer.

The results indicate a greater stability of casein in milk in spring and summer, which will affect the decrease in the rate of its coagulation during rennet coagulation. But the milk of this period had a greater number of small particles, due to which the casein coagulated faster, the clot condensed faster and had a maximum density. It was found that in the milk of the winter and autumn periods, the stability of casein is lower, causing accelerated coagulation of proteins. Thus, in terms of technological properties, summer and winter milk was better than in other periods of the year. It was characterized by better coagulability and syneretic properties of the clot.

The production of cheese requires the study of biological properties. According to the accepted criteria in cheese making, it must be biologically complete. This means that milk is a favorable environment for the development of lactic acid bacteria and the accumulation of enzymes involved in the further ripening of cheese. Biological usefulness is determined by substances that stimulate the development of lactic acid bacteria: vitamins, trace elements, enzymes. When studying the biological properties of milk, it was found that seasonality, climatic conditions affect biological processes. The properties of milk as a medium for the development of lactic acid bacteria change significantly over the seasons and depending on zootechnical factors.

The harvested milk showed a high level of these microcomponents throughout the year. However, the largest amount was in the milk of the summer period for all substances (vitamins, microelements, enzymes). It was found that the concentration of Cu in summer milk was 0.22±0.4 mg/l. This value is considered optimal for the vital activity and development of microorganisms, stimulates the growth of lactic acid bacteria and inhibits the growth of butyric acid bacteria. Therefore, microelements are contained in the optimal ratio in milk and, as a biochemical environment, this will promote the growth of lactic acid microorganisms of the starter and will further lead to a reduction in the ripening of cheese.

In the production of cheese, rennet coagulation of milk proteins is used. To create organoleptic properties, sourdough is introduced into milk in the amount of 0.8-1.2%, the growth of bacterial biomass occurs at different rates throughout the year. The following pattern has been established: in the initial period, active growth of lactic acid bacteria occurs almost along a logarithmic curve. As the lactose content decreases, due to its utilization by microorganisms, new forms are formed - lactates. The hydrolysis of lactose along the path of lactic acid fermentation takes place until the acidity of the medium is 41-47 °T, otherwise their growth stops at higher values of the acidity of the medium.

Further lactic acid fermentation is accompanied by a gradual development of microorganisms with an increase in lactic acid up to 67-100 °T in the case of using lactic streptococci in the starter and 200-278 °T when introducing lactic acid sticks (Fig. 1).

The studies used the selection of starter cultures of lactic acid bacteria according to biochemical properties for directed regulation of the technological properties of milk, improvement of the organoleptic properties of cheese, suppression of vital activity of extraneous microflora;

In cheesemaking, for the formation of taste, smell, pattern, lactose (milk sugar), citrates are necessary as an energy material for biochemical reactions in the vital activity of sourdough microorganisms.

These components of milk increase the intensity of accumulation of the biomass of lactic acid microflora, its bacterial activity. Their quantitative content in milk and cheese by periods of the year is given in Table. 3. The results in Table 3 show a relatively stable content of lactose in milk during the year, and its amount changed in a rather narrow range - from 4.68 to 4.76%. Milk had high lactose values, which indicates a low content of mastitis milk in milk. This indicator indirectly indicates the quality of the harvested milk.

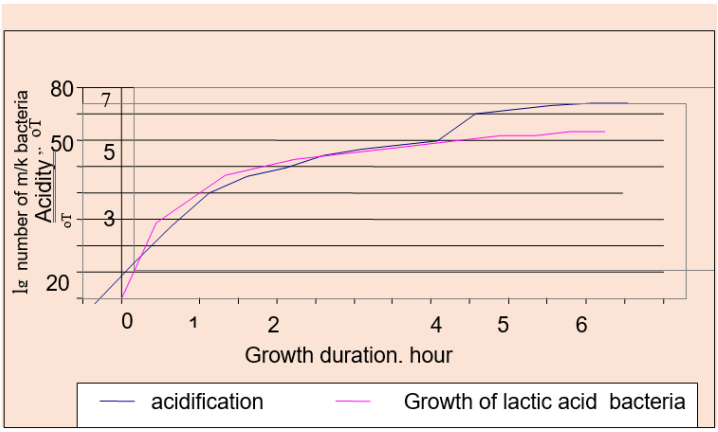

Fig. 1. Growth of mesophilic lactic acid bacteria and acid formation in milk in the summer period of the year

Research results show that the level of lactic acid differed in cheeses produced at different times of the year. It is shown that in the summer period the remaining lactose slowly fermented during the ripening of cheeses and a significant amount of 0.23 % lactic acid was formed within 25 days. Another dynamics of lactic acid fermentation was traced in winter cheeses. During the first 5 days of maturation in winter, the same amount of lactic acid is accumulated in cheeses as for 25 days. In the cheeses of winter workings, the content of lactic acid practically did not change (difference by 0.02%) on the 30th day of maturation. The obtained dynamics of lactic acid growth during the ripening process indicates damping fermentation reactions for cheeses in the winter season.

Table 3. The content of lactose in milk, cheeses and the dynamics of its change (average values)

Period of the year	Mass fraction of lactose. %		Mass fraction of lactic acid. %			Citrates. %
	Milk	Cheese from the press . %	ripening cheese.			
			days	25 days	30 days	
1.Winter	4.76 ±0.02	0.41 ± 0.01	1.28 ± 0.01	1.28 ± 0.01	1.30 ± 0,01	0.17
2. Summer	4.68 ±0.02	0.34 ± 0.02	1.00 ± 0.01	1.23 ± 0.01	1.18 ±0.01	0.18

Another, more intense dynamics was recorded in the cheeses of summer workings. By the 25th day of ripening, the content of lactic acid increased from 1.00 to 1.23%, but by the end of maturation, lactic acid decreased intensively from 1.23 to 1.18 %.

In addition to lactose, citrates are a source of consumption for the vital activity of lactic acid bacteria (gas-forming microflora). Their content affects the rate of formation of carbon dioxide by aroma-forming microorganisms Lc. diacetylactis. In the milk of the summer and winter period, the maximum amount of this component (0.17 - 0.18 %). This will lead to the formation of a sufficient amount of carbon dioxide and the formation of the correct pattern. In the autumn and spring periods, the smallest amount of citrates was recorded, which can lead to an insufficient amount of CO_2 emitted for the correct formation of the pattern, and worsen the taste and aroma.

Therefore, during these periods of the year, when making cheeses, it is necessary to select the composition of the starter, which includes bacterial cultures of gas-forming

microflora, which form carbon dioxide not only from citrates, but also from lactose. In addition, the activity of lactic acid bacteria was reduced during this period (spring) due to the low buffering of milk resulting from a lack of casein.

The high content of lactic acid bacteria, vitamins, microelements in the milk of this cheese-making region, which are necessary for the flow of microbiological and biochemical processes, indicates the biological usefulness of milk in the summer, winter and autumn periods. These factors of the biochemical activity of milk processing are an indicator of the intensification of cheese production.

Thus, the efficiency of cheese making is determined by the quality and yield of cheese. Milk plays a key role in this. Tomsk region is an agricultural region and the quality of milk according to cheese properties is determined by its geographical location, pasture meadows and seasonality in harvesting. This area is characterized by a full-fledged chemical composition of milk, which changes throughout the year. To improve individual indicators, it is necessary to adjust the chemical composition and properties, while reducing the effect of seasonality on the cheese suitability of milk in order to obtain high-quality cheese at any time of the year.

4 Conclusions

Studies have shown that the raw material base of the Tomsk region has its own specifics - the composition of the prepared milk, technological properties and cheese suitability of raw milk are determined by two factors: the geographical location of the raw material zone and the period of the year. An analysis of the experimental material showed the stability of casein in milk in the spring and summer periods, which will affect the decrease in the rate of its clotting. The milk of the summer and autumn periods was subjected to rennet coagulation faster, and the cheese clot was compacted sooner, had a maximum density. Summer and autumn milk with a high casein content of 2.76-2.81% was distinguished by the best technological properties, active growth of lactic acid bacteria, followed by a decrease in active growth in the autumn-winter period. The trace element composition is sufficient to stimulate the development of lactic acid bacteria, creating conditions for their biochemical activity during milk processing. Lactose fermentation was at 91.4% in winter and 92.6% in summer. It was noted that the content of lactose in milk was relatively stable throughout the year, and its amount changed in a rather narrow range - from 4.68 to 4.76%. The dynamics of accumulation of lactic acid in cheeses during maturation by periods of the year has been established. The content of citrates in milk was determined, which determine the rate of formation of carbon dioxide by aroma-forming microorganisms Lc. diacetylactis for cheese patterning.

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