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Main Features of Freezing of Mare's Milk

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Abstract: Consuming of fresh mare's milk is complicated by the fact that unlike other types of milk, it has the character of a very active live product what a few hours after milking begins to change its characteristics, rapidly losing its medicinal properties. To preserve the biological value of freshly harvested mare's milk, a line of shock freezing of pair mare's milk in plastic bags was developed. Thus, we achieve the preservation of the taste qualities of freshly harvested mare's milk for a long period with the full biological activity of all vitamins and enzymes. Travelers have been concerned about passing through a route to reach a specific destination since the distant past. Long routes that caused fatigue and exhaustion or staying in the distant countries and lands for a long time and away from all of the standards of life led to development of a new industry.

Key words: Mare's milk, freezing process, storage of milk, biological activity, development of a new industry

INTRODUCTION

Mare's milk contains about 40 biological components necessary for the human body: the most important vitamins-A, C, B1, B2, B6, B12, amino acids, enzymes and trace elements. The milk is considered to be a curative product and is used in the treatment of impaired metabolism as a remedy for preventing colds and contributing to the cure of cancer. The mare's milk improves blood circulation, accelerates the regeneration of organs (Zaitsev, 2000).

Mare's milk is recommended as a medical and dietary product. It normalizes metabolism, improves health and slows down the aging process. This milk is used for such diseases as disorders in the immune system and stomach ulcers. Koumiss, made from mare's milk is considered a therapeutic and dietary and fortifying product (Wells *et al*., 2012).

Fresh mare's milk has a neutral reaction (what is important for patients with gastritis), it tastes sweet but has a bluish-white to slightly brownish color. Important components of milk are lactose, casein and albumin (with a balanced amino acid composition), omega-3, 6, 9 fatty acids, vitamins, minerals (Potocnik *et al*., 2011).

The effectiveness of mare's milk in supporting and rehabilitating tuberculosis patients is confirmed by scientific studies (Tahmassebpour, 2016), since linoleic, linolenic and arachidonic acids that are part of inhibit the reproduction of the tubercle bacillus, there by contributing to the speedy recovery of patients.

Paired mare's milk, "saumal" is a unique product with amazing curative properties. Our ancestors also noticed how beneficial and versatile it acts on the body: rejuvenates, strengthens, helps with the most serious diseases (Atafar *et al*., 2013).

Freshly harvested milk retains its medicinal properties only for the first two hours. You can drink it for another three hours but the value of the product is noticeably reduced.

Thus, to preserve the valuable qualities of saumala, a shock frost can occur, since during a quick freeze all the biologically active components and vitamins of fresh mare's milk are stored.

The main stages of obtaining milk such as: direct milking of mares, separate weighing of milk received by each milkmaid; pumping milk from the storage tanks of the milking plant to the total intermediate capacity, lead to the fact that the freshly extracted milk is at a sufficiently high temperature for about 2 h. Therefore, even before entering cooling devices or in their absence in tankers of milk carriers, it almost completely loses its healing qualities. One of the ways to increase the term of the biological value of milk is its rapid cooling (Chomanov and Shinginsov, 2016; Ghasemi and Gholamalizadeh, 2015).

MATERIALS AND METHODS

Conducting experimental studies, the possibility of measuring the temperature of the product in the shock freezing chamber using a thermocouple coated with a layer of material whose dielectric constant is less than the dielectric constant of the medium is used. As a thermocouple coating, paraffin with a dielectric constant $\varepsilon<2.2$ was used.

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The milk is frozen with the thermocouple, covered with a dielectric impermeable material in the freezer whose air temperature is -18÷-20°C.

RESULTS AND DISCUSSION

During the freezing process, three temperature ranges can be distinguished at the center of the product: from +20 to 0°C from 0 to -5°C and from -5 to -18°C (Fig. 1). In the first stage, the product is cooled from +20 to 0°C. The temperature reduction in product is proportional to the amount of heat removal work.

At the second stage, a transition from the liquid phase to the solid phase takes place at temperatures from 0-5°C. The work on the heat extraction of the product is very significant but the temperature of the product practically does not decrease but about 70% of the liquid fractions of the product crystallize what calls freezing.

On the third-there is a confinement of product in temperatures from -5 to -18°C. The decrease in temperature is again proportional to the work performed by the refrigeration machine.

Traditional freezing technology, realized in the form of low-temperature refrigerating chambers, assumes a chamber temperature of -18÷24°C. The freezing time in cold rooms is 2.5 h and more. In freezing, the speed of the process assumes a decisive role. A close relationship between the quality of the product and the rate of freezing is established. Numerous experimental data indicate the influence of the freezing rate on the size of ice crystals, on the structural and enzymatic changes in products. The idea of the shock freezing technology consists in forcing the cooling, freezing and food-storage modes of products (Fig. 2). This forcing is provided by two means of increasing the rate of heat extraction from the product. Reducing the environment temperature to -30÷-35°C, accelerated movement of the coolant, leads to unjustified power costs and increased deformations of the product, the unevenness of the process becomes too great.

Further, we conducted studies of the mare's milk freezing process in a freezing chamber cooled by a refrigerating compressor-condenser unit. Packed fresh mare's milk was frozen with a milk thickness in bags -6, 8, 10 and 12 mm, at a temperature of -18 to -20°C for 1.5-2 h.

The freezing regimens of mare's milk have been determined experimentally. The optimal freezing temperature of the selected objects was determined by the amount of frozen water. The numerical value of this parameter depends not only on the energy used for producing the cold but also on the thermodynamic and mechanical characteristics of the products.

To determine the amount of frostbitten water, we examined the thermograms of freezing mare's milk in the temperature range from -10 to -30°C. Analysis of the experimental data in laboratory conditions showed that the freezing temperature of the investigated objects falls from -10 to -20°C, τ-4-5 h, the amount of frozen water increases from 12-14%. In the range from -20 to -30°C, τ-5-6 h this parameter increases on the average by 2.5-3.3%. In this connection, from the economic point of view, the energy costs for producing cold for lowering the freezing temperature of the product are -20°C is not practical. On the basis of the experimental studies carried out, the optimal temperature for freezing mare's milk was a temperature of -18÷-20°C.

Conducting the experimental studies, the obtained thermograms of freezing mare's milk made it possible to determine such parameters as cryoscopic temperature and the amount of freezing water. For the selected objects of investigation, the cryoscopic temperature was respectively for milk in a package of 6 mm -1.5°C thickness, 8 mm -1.8°C thick, 10 mm -2°C thick with a

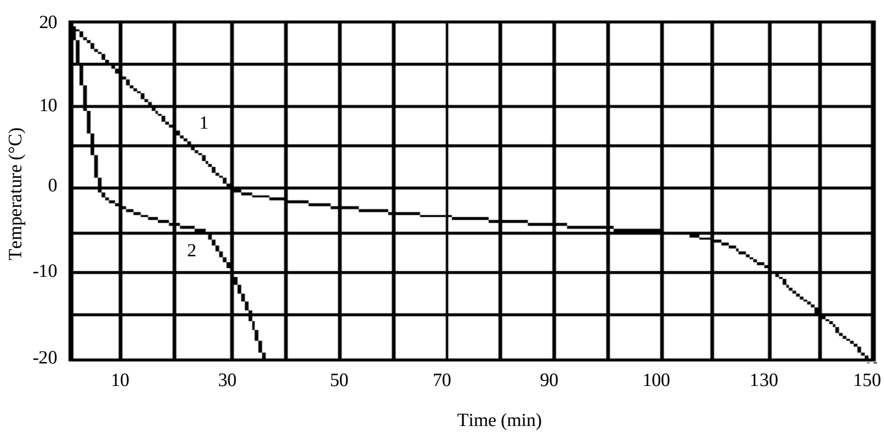

Fig. 1: Milk freezing process

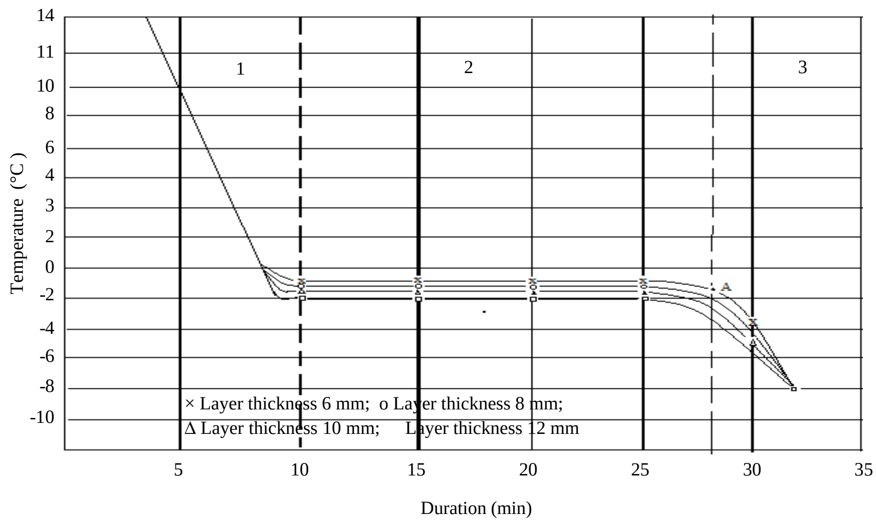

Fig. 2: Mare milk freezing thermogram

thickness of 12 mm -2.2°C (Fig. 2). As can be seen from Fig. 2, the process of freezing mare's milk with different layer thicknesses consists of three periods: a cooling period of 10 min; period of the phase transition, the duration of which is 10-12 min and the freezing period up to a temperature of 8°C, the duration of which is up to 16 min.

We developed a mini line of production equipment for the reception and freezing of mare's milk which is intended to increase the shelf life of mare's milk harvested in tons of remote summer pasture lands and to ensure the possibility of year-round production of fermented milk products (Table 1).

The proposed mini line is designed to receive and freeze up to 100 L of mare's milk per day in the form of a storage tank with a cooling jacket, milk dispensers in plastic bags, a refrigerated cabinet for shock freezing and storage of milk.

Filling of freshly harvested mare's milk is made through packer-dosers in a 500 mL polyethylene bag then stacked in stainless steel trays. In this case, the thickness of the milk layer in the bag in the horizontal position should not exceed 10 mm. Freezing in the chamber of shock freezing occurs at a temperature from -100 to -200°C for 1.5-2 h. Then the milk, frozen in mare packets is transferred to the cold storage and transportation chambers for further processing or drying. Next, we conducted a study of the qualitative characteristics and organoleptic parameters of frozen mare's milk (Table 2 and 3).

Thus, the developed mini line for the acceptance and freezing of pre-packaged fresh mare's milk in remote summer pastures will make it possible to produce frozen milk with preservation of its high quality.

Table 1: Influence of freezing temperature of mare's milk on physico chemical characteristics

Indicators	Fresh milk	Freezing temperature of mare's milk (°C) -10	-20
Density (kg/m^3)	1030	1031	1032.00
Acidity (°T)	6.53	6.51	6.48
Protein (%)	1.25	1.24	1.24
Casein	1.38	1.37	1.32
Sugar (mg/100 mL)	8.42	8.41	8.41
Vitamin C (mg/L)	98.7	95.1	93.40

Table 2: Organoleptic parameters of frozen mare's milk

Indicators	Characteristics
Consistency	Dense, homogeneous with the presence of small ice crystals
Taste and smell	Clean, without foreign tastes and odors
Colour	White with a bluish tinge

The proposed technology of shock freezing of packaged mare's milk reduces the freezing time by 7-8 h in comparison with the freezing of milk in containers which is 8-10 h.

The process of freezing and storage milk in a frozen state does not cause more damage to proteins and fat dispersion than the action of low positive temperatures which can not always be completely eliminated.

Table 3 presents data on the change in the biochemical parameters of mare's milk of summer milking and their changes in shelf life after freezing. From the foregoing, it follows that the change in the composition of milk occurs not during the freezing process but during its storage, i.e., depends on the conditions and terms of its storage in a frozen form. Observation of the dynamics of changes in the biochemical composition of frozen summer mare's milk was carried out for 6 months at a temperature of -15°C.

Table 3: Change of the biochemical composition of frozen milk mare's milk during storage

		Shelf life (month)					
Indicator	Fresh milk	1	2	3	4	5	6
Density (kg/m^3)	1030	1030	1031	1031	1032	1032	1033
Active acidity (pH)	6.53	6.54	6.55	6.56	6.57	6.58	6.60
Dry matter (%)	10.14	10.16	10.23	10.27	10.34	10.41	10.48
Water activity (A_w)	0.9928	0.9931	0.9933	0.9934	0.9938	0.9941	0.9944
Protein (%)	1.25	1.25	1.25	1.24	1.24	1.24	1.24
Fat (%)	1.52	1.52	1.52	1.52	1.52	1.52	1.52

As can be seen from the data in Table 3, a slight decrease in the protein index is observed during storage and an increase in the active acidity is observed and significant losses occur with the content of vitamin C. During storage for 6 months, the content of vitamin C decreases >2-fold.

CONCLUSION

The results of studies on the effect of freezing on the preservation of nutrients in mare's milk showed that the process of freezing does not affect the biochemical composition of milk, small changes occur during storage. In this regard we are recommended to store frozen milk up to 3 months because the biological qualities of mare's milk vary slightly.

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