# Part 1. Veterinary medicine

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## INFRARED MILK PASTERIZER AS A COMPONENT OF SUCCESS IN THE ANIMAL LEUKEMIA CONTROL

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**Summary.** One of the most common and dangerous cattle diseases of oncogenic origin is leukemia. An effective technological step to control animal leukemia and to prevent the possibility of its further spread is milk pasteurization. We have studied the quality of dairy raw materials and equipment used in the pasteurization of milk. The resistance of pasteurized milk was compared after using various methods of its processing (storage in a refrigerator at a temperature of 4–5°C). The comparative characteristics and specific energy consumption of the most popular pasteurizer models with 'UOM' milk pasteurizer-disinfectant were described. We studied the specific energy consumption of the 'UOM' units. It was established that pasteurization of milk in cattle leukemia is an integral stage in the overall complex of veterinary and sanitary measures. For pasteurization in livestock farms and milk processing plants, it is necessary to install modern, energy-saving, highly efficient pasteurizers using infrared heating. When using infrared equipment for pasteurization-disinfection of milk ('UOM'), the disinfection of milk occurs at 79.5°C in a stream (without exposure). This mode of milk processing completely destroys the leukemia virus in it and does not affect its nutritional qualities

**Keywords:** leukemia, milk, pasteurization, temperature, energy consumption, infrared radiation, pasteurizer

**Introduction.** Today, there is a growing demand for dairy products in the world, which is partly due to increased consumer welfare in developing countries. Global dairy trade accounts for only 6.2% of global production, and demand currently exceeds supply (More, 2009).

The quantity and quality of produced milk is closely dependent on a number of factors, both of endogenous and of exogenous origin (Picinin et al., 2019).

The most important factor that determines the quality, as well as the safety of milk for the consumer, is its receipt from healthy animals (Leitner et al., 2013). During pathological processes in the body of a lactating animal, a number of pathogenic microorganisms are released with milk, that can cause serious harm to the consumer (Chaffer et al., 1999). It should also be noted that these microorganisms often have high antibiotic resistance (Hadzevych et al., 2019).

Monitoring of the total number of microorganisms in relation to the quality of raw milk is mandatory, but determining the presence levels of certain types of bacteria is becoming increasingly important (Nightingale et al., 2008). For example, spores of some spore-forming bacteria present in raw milk at very low levels (< 1/ml) can survive after pasteurization and multiply in dairy and cheese products to levels that lead to their defects (Murphy et al., 2016).

One of the most common and dangerous diseases of oncogenic origin among cattle is leukemia (Frie et al., 2017; LaDronka et al., 2018). Bovine leukemia virus is leukemogenic in at least two mammalian species, it is widespread in commercial dairy herds, and can infect a wide range of *in vivo* hosts and cells, including human cells, *in vitro* (Ferrer, Kenyon and Gupta, 1981). Bovine leukemia virus (BLV), an oncogenic member of the genus *Deltaretrovirus*, is closely related to human T-cell leukemia virus (HTLV-I and II) (Polat, Takeshima and Aida, 2017). There is information that the leukemia virus should be considered as a potential predisposing factor for breast cancer in women (Schwingel et al., 2019).

For the control and prevention of leukemia in different countries, different schemes, technological maps and various veterinary measures that have different efficiencies have been developed (Bartlett et al., 2014; Ruggiero and Bartlett, 2019).

An effective technological stage in the control of animal leukemia and prevention the possibility of its further spread, is milk pasteurization (Baumgartener, Olson and Onuma, 1976). This method is widely used not only in veterinary medicine, but also in humane medicine (Gayà and Calvo, 2018), in the processing industry (Stabel, 2003).

The experiments proved that after pasteurization of milk the number of bacteria is significantly reduced, and pasteurized milk contains an acceptable number of bacteria in more than 90% of the samples. These results indicate that pasteurization may be very effective in reducing bacterial contamination of milk (Elizondo-

Salazar, Jones and Heinrichs, 2010). However, the use of malfunctioning pasteurizers as well as a violation of their operation may lead to risks associated with incomplete disinfection of the processed milk (Fernandes et al., 2015).

World practice shows that it is necessary to observe strictly all existing technological steps in the production of milk (Dong, Hennessy and Jensen, 2012; Paliy and Paliy, 2019).

But above all, in order to receive high quality and safe final product, high-quality raw materials and high-quality equipment are needed, that will not reduce all the properties of whole milk during its processing.

**Material and methods.** A study on the issue of quality of milk raw materials and equipment used in the pasteurization of milk was carried out. The resistance of pasteurized milk was compared when processing by various methods (storage in a refrigerator at a temperature of 4–5°C). The comparative characteristics and specific energy consumption of the most popular pasteurizer models with 'UOM' milk pasteurizer-disinfectant were described. We studied the specific energy consumption of the 'UOM' units.

**Results and discussions.** ***Quality raw materials.*** The main suppliers of whole milk to milk processing enterprises are agricultural livestock breeding complexes for cattle. Getting high-quality milk is a laborious and multifactorial process. It should be noted that the faster the milk is cleaned, cooled, and if necessary pasteurized, the more high-quality product will be presented to the milk processing enterprise, and the more profit the farm will receive.

Indicators of milk acidity and bacterial contamination are the most important in determining the grade of milk. To ensure these indicators at the proper level is especially difficult in the warm season. Typically, milk on a dairy farm after receipt is simply cooled and sent to the milk processing plant once a day.

Filtering milk through a non-woven or lavsan filter does not reduce its bacterial contamination, but only reduces the amount of mechanical impurities. It is impossible to cool milk instantly, and the milking process itself lasts 2–3 hours.

All this time, bacterial seeding and the acidity of milk are growing. However, even in pasteurized milk cooled to 4°C, the process of microflora reproduction is slowly continuing. The safety of milk at 4–5°C after infrared (IR) pasteurization is better than after pasteurization in traditional plants (Table 1).

**Table 1** — Comparison of the resistance of pasteurized milk after various methods of its processing (storage in the refrigerator at a temperature of 4–5°C)

| Pasteurization method | Duration of milk preservation without changing its characteristics, days | | | | | |
|---|---|---|---|---|---|---|
| | acidity | taste and smell | resistance | bacterial contamination | by grade: class with considering bacterial contamination | by grade: acidity |
| Infrared | 15 | 16 | 16 | 3 | 9 | 17 |
| Traditional | 8 | 12 | 14 | 3 | 8 | 11 |

As a result, it is problematic to deliver milk of highest grade to the dairy plant in the southern regions. In addition, the milk processing enterprise incurs additional costs for heating of pre-refrigerated milk during pasteurization. Such a sales scheme is not optimal for either the farm or the dairy plant.

Using an IR milk pasteurizer-disinfectant ('UOM'), the farm can make more profit due to the higher grade of milk, and the dairy plant, providing itself with high-quality raw materials, heats the milk that has been pasteurized at the supplier's farm not to the pasteurization temperature, but to the necessary for the technological process temperature. The 'UOM' is essential equipment for the prevention of tuberculosis and leukemia during calf feeding. The disinfection mode (80°C without exposure) allows the milk processing enterprise to use milk after UOM for the production of almost all products, because IR pasteurization-disinfection does not change the technological properties of milk, while traditional disinfection (90°C for 5 min) makes it impossible to use milk for the production of a number of products. Since the supply of high-quality raw materials to the dairy enterprise is beneficial both for the farm and for the dairy plant, it became popular to purchase the infrared pasteurizers by dairy plants for the farms-suppliers, which pay off subsequently the plant on the terms agreed upon in the contract.

***Quality equipment.*** Pasteurization as part of the primary processing of milk can be carried out both on the farm and in the milk processing enterprise. In terms of energy consumption, it is more economical to pasteurize milk at the farm before cooling. Table 2 compares the specific energy consumption of the most popular pasteurizer models with 'UOM'.

As can be seen from Table 2, in terms of energy saving, 'UOM' is far ahead of the same well-known designs of pasteurizers. It should be noted that in the table, the energy consumption of traditional pasteurizers with recovery is given for the 'pasteurization' mode, and for 'UOM' — for the 'disinfection' mode.

**Table 2** — Comparative characteristics of the specific energy consumption of infrared and traditional pasteurizers, kW×h/t

| **Type of equipment** | **Type of technological milk processing operations** | **Real** | | **Perspective** | |
|---|---|---|---|---|---|
| | | **Initial temperature of milk** | | | |
| | | **10°C** | **40°C** | **10°C** | **30°C** |
| Traditional capacitive units | without rinsing and cooling | 176 | 132 | 125 | 93 |
| | without rinsing with cooling | 352 | 264 | 250 | 186 |
| | with rinsing and without cooling | 234 | 176 | 166 | 124 |
| | with rinsing and cooling | 586 | 440 | 416 | 310 |
| | average value | 337 | 253 | 239.25 | 178.25 |
| In-line conventional heat recovery units | without rinsing | 38 | 30 | 19 | 15 |
| | with rinsing | 51 | 40 | 25 | 20 |
| | average value | 44.5 | 35 | 22 | 17.5 |
| 'UOM' infrared pasteurizer | | Basic design | | Promising opportunity | |
| | without rinsing | 15 | 12 | 11 | 8 |
| | with rinsing | 19 | 16 | 14 | 10 |
| | average value | 17 | 14 | 12.5 | 9 |

If for traditional pasteurizers a decontamination regime of 90°C with an exposure of 5 min is ensured, their lag behind the 'UOM' will become even more obvious. There are other, little-known models. The main criterion characterizing the price-quality ratio is the number of equipment in operation. Infrared disinfecting pasteurizers have proved themselves as popular, simple, available and reliable equipment.

Infrared equipment for pasteurization-disinfection of milk ('UOM') is currently the only equipment when using which the disinfection of milk occurs at 79.5°C in a stream (without exposure). At a lower pasteurization temperature, 'UOM' works like a regular pasteurizer.

Thus, if 'UOM' is acquired by an economy trouble for tuberculosis or leukemia, it does not have problems with milk intake at the dairy plant, as sparing pasteurization-disinfection mode (79.5°C without exposure) will preserve all technological properties of the product. Both the temperature effect on milk and the mechanical effect are minimized.

If a high-performance 'UOM' is purchased by a dairy plant, milk after pasteurization-disinfection can be packaged (according to the organoleptic characteristics of the product and the safety of the vitamin composition, 'UOM' is superior to traditional pasteurization equipment, but the product has a longer shelf life).

It is also possible to make almost the entire range of dairy products, butter, cream, hard cheeses, casein, milk powder, and baby food from milk that has undergone IR processing. Lines for the production of all of the above listed products are equipped with 'UOM'.

Modern pasteurization equipment may differ in the way the product is heated. Their common (if this is not a bath for prolonged pasteurization) is the presence of a lamellar or tubular recuperator. It is used to reduce the energy consumption and product outlet temperature. If the customer is in danger of getting into the pasteurization equipment milk with high acidity (> 21°T) or milk with a high colostrum content, the following formula is used:

$$t_r = t_i + \eta_{er} \times (t_p - t_i),$$

where, $t_r$ — product temperature between the recuperator and the heating element;

$t_i$ — initial temperature of the product;

$\eta_{er}$ — heat exchanger recuperation coefficient;

$t_p$ — pasteurization temperature.

If $t_r$, as a result of data fitting, is higher than 68°C, there is a risk of coagulation of the product with a high colostrum content or acidity > 21°T in the recuperator. The probability of this is the higher, the closer $t_r$ is to 82°C. As experience shows, sediments are formed on plates in a lamellar and on tubes in a tubular recuperators when milk with a high colostrum content or acidity > 21°T passes even with fluid motion regimes $Re = 9.0 \times 10^3$, where Re is the dimensionless Reynolds criterion. The 'UOM' is equipped with a lamellar (tubular) heat exchanger, the recuperation coefficient of which is 82–89%. Thus, the specific energy consumption per ton of milk with $\eta_{er}$ = 83%, $t_p$ = 80°C, is 12.5 kW×h/t, with $\eta_{er}$ = 89% — 9 kW×h/t.

Table 3 (basic design of the 'UOM') indicates the specific energy consumption of the 'UOM'.

Electricity consumption can be reduced by increasing the recuperation coefficient. Recently, the 'UOM' acquisition model has become popular, in which the department of raw materials of a milk processing enterprise, providing itself with quality products, enters into agreements with supplying farms and acquires equipment for them under a leasing scheme. The IR pasteurizer-disinfector is equipped with automation and temperature control (Disk-250 recorder), which ensures reliability of temperature control and the ability to control the supplier by the dairy enterprise.

**Table 3** — 'UOM' specific energy consumption

| Characteristics | 'UOM'-5.0 | 'UOM'-3.0 | 'UOM'-2.5 | 'UOM'-2.0 | 'UOM'-1.5 | 'UOM'-1.0 |
|---|---|---|---|---|---|---|
| Productivity, l/h | 5,000 | 3,000 | 2,500 | 2,000 | 1,500 | 1,000 |
| Initial temperature of milk, °C | 6–30 | | | | | |
| Milk processing temperature, °C<br>at tuberculosis<br>at leukemia | <br>79 ± 0.5<br>79 ± 0.5 | | | | | |
| During pasteurization | 70–80 | | | | | |
| Output product temperature, °C | 16–40 | | | | | |
| Installed power, kW | 50 | 38 | 34 | 29 | 22 | 15 |
| Specific energy consumption for the processing of one ton of milk, kW×h/t | 9–12 | | 11–14 | | 12–15 | |
| Weight of the equipment, kg | 700 | 450 | 400 | 350 | 300 | 250 |
| Occupied area, $m^2$ | 4 | | | 3 | | |

A peroxidase test at such a low pasteurization-disinfection temperature will not show high-quality pasteurization. Therefore, either milk is accompanied by a pasteurization thermogram, or the quality of pasteurization is checked by a phosphatase test, or the pasteurization temperature is increased to 86°C.

In leukemia, milk from seropositive animals kept in isolation from the seronegative herd is pasteurized in the farm at temperatures not lower than 80°C (only in this mode it is possible to control the quality of pasteurization by reaction to peroxidase), after which it can be used to feed calves or to send to the dairy enterprise. The milk from the cows of the seronegative herd can be sold to processing plants without preliminary pasteurization. In the case where the leukemia seropositive animals are not separated from the total herd, milk from the entire livestock population of the farm is pasteurized in the specified regimes. In some cases, with the written permission of the Chief State Inspector of Veterinary Medicine in regions, cities and districts, temporarily export of raw milk by separate transport to the dairy plant for technological pasteurization and further processing, is allowed if there is a separate line at the dairy processing plant for receiving such milk.

Milk from seropositive animals kept in isolation from the seronegative herd may be skimmed in the farm. At the same time, only the pasteurized cream is taken to the dairy processing plant, the skim milk is boiled and fed to the animals.

Milk from cows with clinical-hematological signs of leukemia should not be used for nutritional purposes and fed to animals. Such milk is neutralized by the addition of 5% formaldehyde or other disinfectant.

**Conclusions.** Pasteurization of milk in cattle leukemia is an integral stage in the overall complex of veterinary and sanitary measures. For pasteurization in livestock farms and milk processing plants, it is necessary to install modern, energy-saving, highly efficient pasteurizers for infrared heating. Infrared equipment for pasteurization-disinfection of milk ('UOM') is equipment when using which the disinfection of milk occurs at 79.5°C in a stream (without exposure). This mode of milk processing completely destroys the leukemia virus in it and does not affect its nutritional qualities.

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