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SCIENTIFIC RESEARCHES AND METHODS OF THEIR CARRYING OUT:  
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### **HIGH TEMPERATURE PROCESSING OF RAW MILK**

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# PROGRAM

IV Correspondence International Scientific and Practical Conference

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**EUROPEAN  
SCIENTIFIC  
PLATFORM**



**ICCM**  
International Centre  
Corporative Management

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## **HIGH TEMPERATURE PROCESSING OF RAW MILK**

Modes of pasteurization of raw milk, which are used in the production of hard rennet cheeses, do not destroy all microflora. Even pasteurization of milk at a temperature of 75...76 °C for 20-25 seconds, which corresponds to the upper limit of heat treatment of raw milk in the production of hard rennet cheeses, provides only 94.6% efficiency of heat-resistant bacteria.

Adopted modes of short-term pasteurization for most rennet cheeses at the level of 72...76 °C with a holding time of 20-25 s allow to achieve the residual amount of bacterial contamination of milk at 72 °C pasteurization mode - 3.2%, at 76 °C pasteurization mode - 0.7 %

UHT processing.

During UHT processing (= ultra high temperature), almost all bacteria and spores are destroyed due to intensive heat treatment (140 °C/3...4 s). Ultra-pasteurized milk can contain mesophilic spore formers that produce spores with extreme heat resistance. These spores are designated by the term HRS (= heat-resistant spore forms). Their sporulation is very low (1:1,000); moreover, they show only low metabolic activity. Carbohydrates are not attacked, enzymes that break down proteins (proteases) are barely visible, but they are not very active (HAMMER, etc.).

From a microbiological point of view, UHT milk would be an ideal raw material for a cheese factory, as the yeast could multiply without any inhibitions; however, the denaturation of protein, especially whey protein, is so great that rennet coagulation, despite technological means, will be very difficult. Therefore, UHT treatment of curd milk and ready-made concentrates is used only in some very exceptional cases.

The use of membrane separation methods (ultra- and microfiltration - separation limits of 0.1) allows the use of new technologies for the production of cheese from UHT-based material (Schreiber and Huber). It has been proven that this extreme heat treatment is useful for inactivating bacterial concentrates or bactofugates that are formed during bactofugation and microfiltration. The indirect UHT process is less energy-intensive due to heat recovery compared to the direct UHT process.

Transonic processing.

Velocities exceeding the speed of sound in the environment are considered ultrasound. The speed of sound depends on the equilibrium density and properties of the surrounding material. In the air The speed of sound is 331 m/s, and in water – 1464 m/s. In liquids, it can be calculated using the following formula:

$C_s$  = Speed of progressing waves of sound in a liquid medium

$C_s = \sqrt{1/C \times \rho_0}$   $C$  = Compression module

$\rho_0$  = Density equilibrium.

A comparative study of transsonic inactivation and pasteurization was conducted [1]. This new technology is based on the principle of increased compressibility of homogeneous two-phase flows compared to the compressibility of liquids or gases alone. The transonic apparatus is internally divided into 3 sections. The first two sections are connected through holes with compressed air tubes to the feed tanks. Injecting steam through a small nozzle into the first cavity creates a vacuum, as in the second cavity. Thanks to this rarefaction, the intake valve opens (after it is unlocked) and the medium is sucked in by itself.

The diffuser, directed against the flow and acting as a nozzle for homogenization, limits the third cavity. The steam and the medium to be treated are mixed with each other in a two-phase mixture in the lowest cross-section of the inlet of the device. A huge speed is reached, which leads to pressure pulses and to the breakdown of the vapor phase. Another state of hydraulic flow is generated, and the heated liquid (milk) subsequently leaves the device under increased pressure. This operating stage combines the main operations of the unit, such as pasteurization, homogenization and, in addition, conveying (pumping by means of a pressure difference), suction (forming a vacuum), mixing and dosing.

Such transonic inactivation of milk microbes is at least equivalent to heat treatment in a heat exchanger. As a comparative study showed, the reduction of inactivation and enzymes, as well as the denaturation of whey protein, are largely similar. Homogenization shows not only the disintegration of fat globules, but also the loosening of the protein structure. The results are a slight reduction in rennet coagulation time and a softer gel associated with significantly reduced liquid separation

(syneresis). The transfer of fat (milk → cheese) is indeed greater, but the transfer of defatted dry matter is somewhat reduced.

Ultrasonic processing.

Sound with a frequency >20 kHz is considered ultrasound. This leads to the dispersion of many substances. Ultrasound technology is very energy-intensive (Villamiel et al., 1999), but very versatile and is used in:

cleaning of installations;

breakdown of fat globules, as well as casein micelles;

enhancement of various processes, such as the extraction of enzymes during important transformations (coagulation and ripening of cheese);

inactivation of bacteria and enzymes (Villamiel et al., 1996).

At frequencies of 15...25 kHz, the cell walls are destroyed, the cause of which is cavitation in combination with the formation of large shear forces, which leads to a very high temperature rise within a few seconds. Because of this huge influx of energy, the cytoplasmic membrane detaches from the cell wall, the cell contents are thrown out, and the cells die. Treatment with a microwave field can be carried out both intermittently and continuously, where the latter method is preferable. The effect of ultrasound depends on several criteria: technical/technological characteristics of the product; exposure time; pH value - viscosity; intensity; fatness; temperature.

*Table 1*

**Effects of product data on effects of ultrasound**

Product- Data	Effect weak good	
	weak	good
pH-value	pH 7	pH ~6.8 and >pH 7.1
Viscosity	high high	low low
Fat content	>10...<70 °C	~10 °C and ~70 °C

Adequately tempered and standardized (fat content and other) milk is exposed to 18...20 kHz and >2000 W. Depending on the conditions, 30 seconds is enough, sometimes it takes several minutes. During this time, the localized pressure can increase to 100 MPa, and the involuntary temperature can reach 134 °C. With

increasing pressure, especially in combination with increasing temperature, the inactivation of microbes increases.

Gram-negative microbes are more sensitive than gram-positive and cocci. Heat-resistant spores of *Bacillus cereus*, *Bac. stearothermophilus* and *Bac. coagulans* are destroyed at 20 kHz, 30 bar and 112 °C. Peroxidase, lipoxidase and polyphenol oxidase are inactivated. According to Roiner, the yield and consistency of the cheese can be improved. However, the fat is broken down, resulting in flavor defects such as «greasy» and «cooked» (Thomet et al.).

#### Pulsed high-energy fields for the inactivation of microbes

Milk is exposed to high-energy pulses. Generated voltage pulses intensively affect cell walls. Cell walls become porous at certain levels of field strength - for larger yeast cells from 5 kV/cm and above, and for bacterial cells from 20 kV/cm - and cell contents can be released. In this way, it is possible to achieve a reduction in the number of non-sporing bacteria by 4...5 log. Spore inactivation is possible under certain conditions. Native milk enzymes lose their activity at, for example, 21 kV/cm for 100 s at the level of 65%; alkaline phosphatase and lactoperoxidase lose only 5...25%. The content of vitamin C is reduced to 90%. It will have almost no effect on the main ingredients of the milk (Hulsen).

#### High pressure process.

In work [2] he described processing of milk under high pressure to increase the shelf life of milk. Pressure-induced inactivation of vegetative cells occurs in a continuous process. Cells undergo several stages of damage. Based on this hypothesis, a model of inactivation of vegetative microorganisms is shown, where the state of cells is characterized by physiological reactions (Table 2).

*Table 2*

**Phase and characteristics of the state of cells**

Phase	Characterisation
Cell is not damaged	<ul style="list-style-type: none"> <li>▶ All functions available</li> <li>▶ Growth even under non-optimal conditions</li> </ul>
Sublethal damage	<ul style="list-style-type: none"> <li>▶ Growth only under optimal conditions (nutrients, temperature, pH)</li> <li>▶ Increase of lag phase</li> </ul>



	▶ Membrane damage due to loss of cell contents and colorisation
Lethal damage	▶ No growth even under optimal conditions ▶ Physiological functions, e.g., acidification partially available
Cell death	▶ Absolutely no physiological functions

Since then, this process has been improved several times. For milk, hydrostatic pressures of 100...800 MPa for 60...2 min at 20...30 °C proved to be useful. The total amount decreases depending on the pressure and the time the pressure is held. Individual microbes show different sensitivity to pressure, as shown by LUDWIG using the examples of *E. coli*, *Ps. aeruginosa*, and *Staph. aureus*. With increasing temperature (30–40 °C), this effect increases and is very effective - for *Bacillus* sp. spores (20 - 40 - 60 °C). Spores are very resistant to pressure treatment, their germination time is dramatically accelerated (90...95%). This effect is used because the milk is pre-treated at 101 MPa/50...60 °C. During further exposure (20 °C/45 min) at atmospheric pressure, microbes multiply rapidly, and newly formed spores are inactivated during the second treatment at 202...405 MPa/50...60 °C [3] .

**Conclusions.** Thus, high temperatures of heat treatment of milk lead to changes in the salt and protein composition of milk. These changes have both negative consequences - deterioration of rennet coagulation of milk and syneretic properties of curd, and a positive result, which consists in increasing the transition of milk solids, primarily whey proteins, into curd and curd.

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