

Sterilization of Milk by Ultrasonics

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Abstract—The results of the experiments on milk processing by ultrasound are presented in the paper. It is shown a fundamental possibility of milk sterilization and pasteurization by ultrasonic fluctuations. The duration of milk processing necessary for their attainment at different modes is determined. This study is chiefly intended for the developers of ultrasound devices and specialists of dairy industry.

Index Terms— ultrasonic processing equipment, milk, sterilization.

I. INTRODUCTION

STERILIZATION of Milk is made to obtain a safe product from sanitary-and-hygienic point of view and to provide its long storage at an ambient temperature without the change in quality.

Sterilized production has a number of attractive properties, as for manufacturer, so for consumer. The losses accompanying the realization of perishable production are reduced (they compose to 20 % from the volume of the product). Sales of the product are increased due to the expansion of a trading area of the enterprise. Long storage life and the possibility of storage at usual temperature modes allow transporting this production to distant regions. Consumers are attracted by the guaranteed product quality and the possibility to use it while traveling [1]. In this connection, the problem of the improvement of milk sterilization methods is of great importance.

One of nontraditional types of milk processing is ultrasonic processing. At present time, ultrasonic devices for homogenization [2,3,4] are used at milk processing. It is worth to note that the data concerning milk sterilization in industrial conditions has not been published yet.

II. METHOD OF EXPERIMENTS

The experiments on milk sterilization were made by ultrasonic oscillations. It was used a whole raw milk received during spring stall period of 2005. The mass fraction of fat in the samples varied from 3.2 to 3.4 %, the mass fraction of protein - from 2,4 to 2,9 %, density - from 1025 to 1029 kg/m³, titrated acidity - from 13 to 17 °T, heat resistance corresponded to groups 2-4.

Ultrasonic irradiation was carried out using ultrasonic technological device "Crystal" (model USCI-0.4/22-M) at the frequency 22 kHz and consumer power 90, 120 and 150 W.

The milk was subjected to ultrasonic processing of the volume 240, 160 and 80 ml. The total amount of bacteria in raw milk was determined by the test with the indicator methylene-blue and the method of limit dilutions. The amount of bacteria in milk ranged from 7.5·10⁵ to 9,3·10⁶ TMA/cm³ (TMA – total microorganisms amount), that corresponded to I-III class. The efficiency of pasteurization and sterilization was estimated by the change of total amount of bacteria (it was determined by the method of seeding in agar-agar nutrient medium) and peroxidase test.

III. RESULTS AND INTERPRETATION

The dependence of total amount of microflora on the duration and consumer power of ultrasonic oscillations and the volume of the processed milk is shown in Figure 1.

According to sanitary standards, the acceptable amount of anaerobic and facultative anaerobic microorganisms in the pasteurized milk is more than 5·10⁴ TMA/cm³ for pasteurized milk in bottles and packages of group A; not more than 1·10⁵ TMA /cm³ - for group B; and not more than 2·10⁵ TMA /cm³ - for pasteurized milk in flasks and tanks. The total amount of bacteria in sterile milk should compose not more than 100 TMA /cm³ per 1 ml.

The effect of pasteurization was observed after 11, 6 and 7 min. for the capacities 90, 120 and 150 W correspondingly at the processing in the volume 240 ml. At the reduction of volume necessary to achieve pasteurization, the time of scoring took 9, 6 and 5 min. for volume 160 ml and 4, 3; and consumer power 2 min. - for volume 80 ml at the same capacities.

Thus, the duration of ultrasonic processing was reduced approximately in three times to obtain the pasteurization at the reduction of the volume in 3 times.

The analysis of the change of ultrasonic processing duration at the constant volume in the dependence on consumer power showed that the increase of the capacity in 1.7 times (from 90 to 150 W) led to the decrease of the processing duration in 1.6 times for the volume 240 ml, in 1.8 times for the volume 160 ml and in 2 times for the volume 80 ml.

The effect of sterilization at milk processing of volume 240 ml was observed after 20, 16, and 11 min. for the consumer power 90, 120 and 150 W correspondingly. The duration of scoring was reduced to 12, 9 and 6 min. at the volume reduction to 160 ml, and at the volume reduction to

80 ml - to 5, 4 and 3 min. for the capacities 90, 120 and 150 W correspondingly.

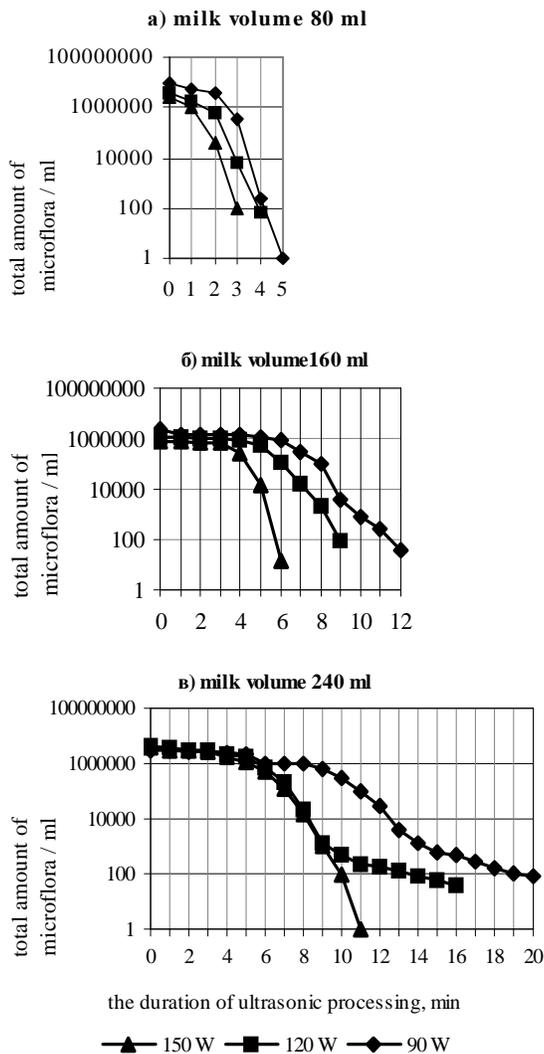


Fig.1 – The dynamics of the reduction of total amount of microorganisms at the processing in the dependence on the capacity of ultrasonic fluctuations and the volume of the processed milk

Thus, the duration of scoring necessary to achieve pasteurization and sterilization effects was reduced at the increase of the capacity of ultrasonic influence and especially – at the reduction of the volume of the processed milk. The efficiency of sterilization made up from 99.9998 to 100 %.

To produce the sterilized milk by the method of ultrahigh-temperature processing, it was used milk with the amount of bacteria by reductase test of the class not less than class I. But the milk of I-III classes was used during the experiments.

In the dairy industry, the efficiency of pasteurization is supervised by the peroxidase test using chloride p-phenylenediamine. The method of the analysis is simple enough; the method sensitivity allows finding out the addition of 5 % of

not pasteurized dairy products to pasteurized products at the temperature not less than 80 °C [5].

The peroxidase test was carried out in all the experiments. In the cases when the total amount of bacteria corresponded to the requirements shown to pasteurized and sterilized milk, the test gave a negative result. Thus, the method allows evaluating the efficiency of pasteurization by ultrasound objectively.

Note that the effect of pasteurization was achieved little bit earlier than peroxidase inactivation at the consumer power of ultrasonic oscillations 90 W in the volumes of 240 and 160 ml of milk. The temperature of milk after ultrasonic processing was below 80 °C in all the experiments (and it was equal from 64 to 77 °C). The peroxidase decayed more quickly at the scoring than at thermal processing of milk. The mechanism of inactivation of enzyme requires more detailed study.

IV. CONCLUSION

Thus, the following conclusions can be made:

- it was shown the basic opportunity of pasteurization and sterilization of milk by ultrasound,
- the duration of scoring necessary to achieve pasteurization and sterilization effects is reduced at the increase of the power of ultrasonic influence and the reduce of the volume of the processed milk,
- the efficiency of ultrasonic sterilization ranges from 99,9998 to 100 %.
- the efficiency of pasteurization carried out by ultrasonic processing can be objectively evaluated by peroxidase test.

The researches in the given direction should be continued. The carrying out of ultrasonic processing of milk in a flow allows reducing the duration of scoring and, further, to develop an industrial line of the obtaining of sterile milk.

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