RESEARCH STERILIZATION PROCESS OF RAW MEAT USING ULTRASONIC

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Abstract: In the article the scientific studies of the process of the sterilization of meat raw material with using the electro-physical method are represented. The known methods of sterilization are analyzed, estimation of these methods is given, and their deficiencies are also revealed. The method of the sterilization of the meat raw material is based on the use of ultrasonic waves is proposed. It is represented experimental data obtained in the course of scientific studies in the department of the catering equipment of Kharkiv State University of Food Technology and Trade.

Keywords: meat, ultrasonic, microflora, ultrasonic frequency

Today one of the most advanced food industry is a meat-processing, which provides the population with food products, which are the main source of protein. The main cause of spoilage of meat and meat products is the presence of unwanted activity of microorganisms that are part of the product. Thus, to extend the shelf life of raw meat, manufacturers use different methods: treatment of cold, carbon dioxide, nitrogen, ozone, ultraviolet radiation, heat treatment product ambassador, smoking, drying and other. But these methods change meat structure a little, it gets dark or there is a necessity of constant support of low temperatures at storage and, as consequence, - high energy costs of operating the compressors. These deficiencies can get rid with the use of ultrasonic emission.

The influence of ultrasonic waves contributes to the complete retention of the food and gustatory properties of the product universality, which makes it possible to use them in different technological processes. Efficiency appears because of the use of pulse technologies.

Studies domestic and foreign Scientifics I. Elpiner, I. Rogov, V. Gorbatov, U. Zayac, V. Khmelev, dedicated to a question about the use of ultrasonic waves, based on the properties and the specificity of the action of ultrasonic fluctuations on the biological subjects.

It is proven that at the basis of the ultrasonic working of meat raw material lies the energy action of ultrasonic fluctuations on the cellular structure of the meat, with which occurs the disturbance of the integrity of both the muscular fibers and the elements of connective tissue.

Today ultrasonic fluctuations in the meat industry are used for the intensification of the process of salting, melting of fat and improve the quality of meat and meat products.

Thus, the improvement of the process of the sterilization of raw meat under the influence of ultrasonic waves and its equipment formulation is urgent scientific and technical task.

Meat is a good nourishing substratum for many microorganisms, in which they find all necessary for themselves substances - the sources of carbon and nitrogen, vitamins, mineral salts. The content of available water and ph of meat also influence their evolution, in connection with which meat is quickly spoiling.

Muscles of healthy animals are, as a rule, sterile. Muscles of sick animals can contain microorganisms. Among lifetime infection, muscles can go to seed by microbes after killing the animal: during the initial processing and the separation the flourishes, from the tools, from the hands and the clothing of workers, and also during transportation, the storage, the packing at commercial points, etc.

Therefore, even fresh meat is not sterile and it contains one or other quantity of the microorganisms [5].

The semination of the fresh cooled meat by microorganisms can be different depending on the maturing degree of meat, temperature and humidity regime of cooling, sanitary-hygenic conditions of production, etc.

To 1 cm^2 of surface are counted thousands, hundreds of thousands of cells.

The composition of microflora is diverse. It is

dominated that this the aerobic and facultative-anaerobic, asporous, gram-negative rod-shaped bacteria of the generation of Pseudomonas, Flavobacterium, Alcaligenes, Aeromonas, bacterium of the group of coliform bacterium, korineformnie bacterium, lactic acid micrococci. In smaller quantities are discovered the aerobic and anaerobic spore-forming bacteria, yeast, and mould spores. Among these microorganisms it is numerous possible pathogens of spoiling the meat, which can actively acting on the proteins, the fat and other substances that are its composition.

Meat can be infected and by the toxigenic bacteria, for example, of clostridium of perfringens, by Salmonella, Bacillus of cereus, by enterococci. Salmonella frequently cause intestinal diseases in large livestock; after that animals for a long time are bacillus carriers. The penetration of Salmonella to the muscles is possible in animal life. During the significant multiplication of such bacteria the meat can serve the cause of poisoning [5].

Being multiplied under the favorable conditions on the surface of meat, microorganisms gradually penetrate into its thickness.

The penetration of bacteria in the thickness of raw meat indicates about reduction in its quality. Decisive importance for the speed of the multiplication of microorganisms on the meat, which stored in cooling form, has temperature that shown in the table 1.

Table 1. Temperature for the period of reproduction of microorganisms in raw meat products

Temperature, °C	Period of the growth, days		Period of appearance the signs of spoiling of meat, days
	Bacteria	Mould	
-0.5	7	14	14
-1.1	7	14	24
-3.3…-2.2	25	25	43
-5.5…-4.4	135	65	155

The signs of the spoiling of product are manifested with the accumulation in it of bacteria in quantity 10^7… 10^8 in 1 g or to 1 cm^2 of its surface (depending on the form of bacteria and product). Ripening period of this “threshold” concentration of microorganisms depends in essence on the temperature of storage and their initial number, which can multiply at this temperature. Thus, when the initial degree of the seeding of meat of 10^4 cells to 1 sm^2 of surface, period of storage at a temperature 0… -1 ° C is 7… 9 days, when the initial degree of the seeding of meat of 10^5 cells - 3… 4 days, and with 10^8 - 1 day.

Meat and meat products in the normal conditions remain comparatively not long; therefore they carry to the number of perishable products. Most often the cause for the spoiling of meat is the microflora, especially rotten, and also the influence of its own ferments of cloth. The meat and meat products immediately after obtaining preserve for the purpose of advancing from spoiling and increase the period of storage, using these or other methods.

The aim of canning is the creation of such conditions, with which the microflora cannot exist or perishes, but the activity of the ferments of cloth concludes or substantially slows down.

Meat and meat products in this case must maximally preserve food nourishment value and initial properties.

Any method of canning must be harmless, and not have negative influence on the quality and the organoleptic indices of the product [3, 4].

Based on analysis of scientific and technical information is developed the classification of the methods of the disinfection of raw meat (figure 1). In connection with the fact that processing of raw material in the indicated methods is based on the principles of the classification of processes and apparatuses for food productions, the classes of chemical, food and technological processes are assumed as the basis of classification. Disinfection of the product means the impact on him of such processing; in which all organisms and resistant enzymes lose their activity. Disinfected products keep a good quality over the long term of time in the necessary conditions for it [3].

Raw meat that can be stored for a long time without the damage has plenty of advantages for both the manufacturer and for trade but also for consumer. Producer may, for example, reach a geographically wider market, make transportation easier, using fewer and cheaper vehicles, and prevent the return of unsold product.

Convenience for customers is achieved by means, for example, customer has no need to overpay for a kind of water, at unfreezing of meat at home and customer has the ability to purchase wholesale meat without fear of its deterioration through short-term period.

When bacteria or spores are exposed to ultrasound radiation or any other method of disinfection, not all microorganisms can be destroyed immediately. Indeed, for a given period of time some of bacteria were killed, while the rest - survive. If we use disinfection by ultrasound radiation effect again on the bacteria remaining on the first portion of the impact during the same period of time, the same part of bacteria will be killed.

So, the given action of ultrasonic vibrations kills the same proportion of the existing microorganisms. Thus, for continuous disinfection by ultrasound radiation it is proposed to handle raw meat of single-dose irradiation increased so that the overcharge livelihoods microflora.

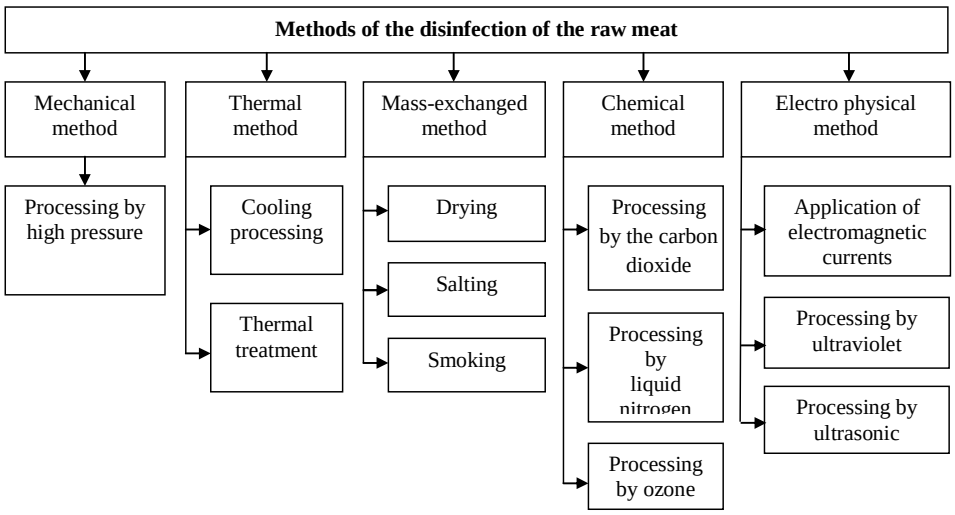

Figure 1. Classification of the methods of the disinfection of raw meat

Based on above mentioned experiments were conducted to establish the optimal duration of exposure required ultrasound on raw meat.

While reviewing the literature [6, 7] we can determine that the main indicator of the effectiveness of the process is a constant efficiency of sterilization effects of radiation on materials.

Thus, the formula (1) determines the constant influence of radiation sterilization efficiency of ultrasound on raw meat at varying duration of treatment

$$K = log\ N/N_t \quad (1)$$

where

K – constant of the efficiency of sterilization by radiation exposure to ultrasound raw meat at varying duration of treatment;

N – number of microorganisms that were present before ultrasound treatment, [unit of number];

N_t – number of microorganisms that were present after ultrasound treatment, [unit of number].

Thus, the lethal effects of ultrasonic disinfection on microorganisms can be expressed mathematically as a logarithmic function, which never reaches zero.

That is, it is impossible to achieve disinfection, which determines the absence of living bacterial spores in an unlimited volume of the product.

There is the definition "effectiveness of sterilization", which sets the number of spores in microorganisms, which is reached after a process of raw meat disinfecting by ultrasound.

The process of disinfection of raw meat can be characterized by some performance results of the application required for this option - time. When the desired length of time is reached (it can be determined after the study of the process), the processing of ultrasonic radiation is most effective, i.e., higher efficiency of decontamination.

However, during ultrasound treatment there is a local increase of temperature from the surface in the direction to the centre of raw meat due to absorption of wave energy. This is a deterrent, because increasing of the temperature rate of raw material to 30 °C leads to denaturation of proteins [1, 2].

In literature there are no data which can identify the impact of duration of the dependence of ultrasound treatment on the surface temperature of raw meat, that why we make necessary research.

Taking into account the fact that ultrasonic waves affect the temperature change of raw meat, we conducted some research to determine the dynamics of change in the temperature in the processing of ultrasonic waves of frequency 22 kHz.

Decontamination by ultrasound can take place both at low and at high frequencies. While disinfection of raw meat the most promising is application of low-frequency ultrasound as well as at high frequencies due to the high energy direction in depth, the relief of the material is in the shadow of a sound and is not the subject of cavitation action. Low frequencies were widely used, because their application occur cavitation at low intensity of ultrasonic vibrations. Increasing of frequency over 22 kHz is also undesirable because of the increased threshold cavitation in the liquid, increasing of the minimum value of sound pressure required for the occurrence of cavitation at the given conditions.

The advantage of low frequency is strong cavitation at a lower intensity of the sound, and large waves contribute to a greater distribution of fluctuations. At a low frequency raw meat begins to vibrate, which is also intensifying its disinfection [1].

Thus, for research we took an ultrasonic frequency range of 22 kHz.

Processing of the results of the research was conducted by means of on-wide procedure. The definitions of experimental data in research point

were measured at least 5 times. Then were done the calculation for measurement errors and were checked for the presence of gross errors.

Figure 2 shows the results of indicated temperature of samples of raw meat during processing by the ultrasonic radiation to extend shelf life.

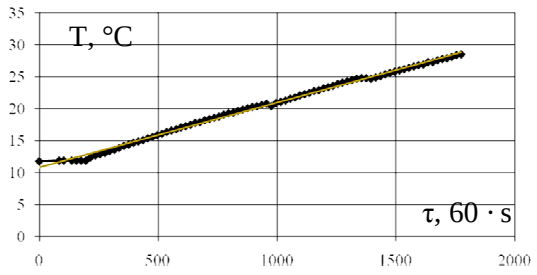

Figure 2. Graph of the dependence of the temperature of samples of raw meat from time period of ultrasonic radiation

As a result of mathematical processing it can be concluded that the temperature dependence of samples of raw meat from the time of ultrasonic radiation can be determined by the formula (2) with a coefficient of reliability approximation $R^2 = 0.996$:

$$y = 0.0102 \cdot x + 10.805, \quad (2)$$

where

x – duration of ultrasonic waves, s;

y – temperature of raw meat in the processing of ultrasonic waves, °C.

While determining the results of the study we took an error ±5% of the number of microorganisms remaining after a given duration of ultrasonic radiation.

An average value of the number of CFU after handling raw meat by ultrasound was taken at each of the periods (10, 15, 20 and 25 minutes), data are given in Figure 3.

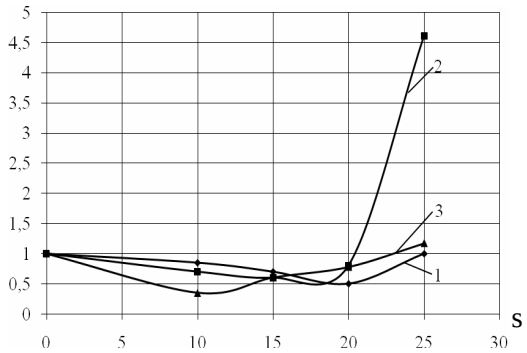

Figure 3. Kinetics of changes in the relative number of CFU at different duration of ultrasonic processing and storage: 1 – after processing by US; 2 – after 2 days storage; 3 – after 5 days storage

According to the table and on the basis of an average number of CFU after handling raw meat by ultrasound we have schedules of dependence of the relative number of CFU on the duration of ultrasonic radiation, shown in Figure 3.

According to the results of mathematical calculations we can conclude that the dependence of changes of different duration of ultrasonic processing and storage of raw meat can be determined by formulas (3, 4 and 5):

$$y_1 = 5 \cdot 10^{-7} \cdot x^2 - 0.0073 \cdot x + 0.9922, \quad (3)$$

$$y_2 = 4 \cdot 10^{-6} \cdot x^2 - 0.0046 \cdot x + 1.2105, \quad (4)$$

$$y_3 = 1 \cdot 10^{-6} \cdot x^2 - 0.0015 \cdot x + 0\text{-}9802, \quad (5)$$

where

x – duration of processing of raw meat by ultrasonic waves, 60 s;

y_1 –relative amount of CFU that remain after processing of raw meat;

y_2 – relative amount of CFU that remain after storage of raw meat for about 2 days in chilled space at 4 °C;

y_3 – relative amount of CFU that remain after storage of raw meat for about 5 days in chilled space at 4 °C.

Thus, the results indicate the feasibility of using ultrasonic waves for sterilizing raw meat.

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