Development of technology for cooked smoked lamb products using ultrasonic treatment

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Abstract. Cooked smoked lamb products belong to the category of delicacies with dietary properties. However, they are not widely used in the food market of the Russian Federation due to the complexity and duration of the technological process. In addition, the multi-stage delicacies making process contributes to the contamination of raw materials with microorganisms. The purpose of our research was to develop a technology for cooked smoked lamb products and the study of low-frequency ultrasound effect on microorganisms - possible contaminants of meat raw materials. Exposure to ultrasound at 35 kHz for 2 minutes inhibited the growth of C. albicans by 33.3%, E. coli by 43.8%, B. subbillis by 46.8%, S. aureus - by 80.6% in comparison with the control samples. After sonication at 26 kHz and exposure for 1 minute, the growth rate of C. albicans decreased by 50%, E. coli - by 64.6%, B. subbillis - by 89.1%, S. aureus - by 86.8% in comparison with control samples. With an increase in the treatment time, the growth rate of the studied bacteria decreased up to 90-98%. An organoleptic assessment of cooked smoked lamb delicacy after 6, 8, 10 and 12 hours of ultrasonic salting showed that the sample with a 12-hour salting had the best organoleptic properties. The developed scheme of smoked cooked lamb delicacies helps to improve the sanitary condition of the raw meat salting process, accelerate the product yield and improve the organoleptic properties of lamb delicacies.

1. Introduction

Cooked smoked lamb products belong to the category of delicacies with dietary properties due to the high nutritional value of young lamb and the special aroma of raw materials [1]. Due to the complexity and duration of the technological process, they are not widely used in the food market of the Russian Federation. However, the results of our research indicate that the ultrasonic treatment of meat raw materials with an ultrasound frequency of 26 kHz and an intensity of 1 W/cm² can contribute to a significant intensification of the meat curing process and improve the physicochemical properties of raw materials [2].

In addition, the long multi-stage delicacies making process, involving the addition of spices and other ingredients, as well as the use of tap water, contributes to the contamination of raw materials with
microorganisms, such as microscopic fungi, *E. coli* group bacteria and others [3].

Our preliminary studies have shown that low frequency ultrasound has bactericidal properties against mycotoxin-producing molds [4]. A mechanism of bactericidal activity of low-frequency ultrasound is that a cavitation cavity filled with steam is formed in the microorganisms’ cytoplasm. Pressure in the bubble leads to the disintegration of cytoplasmic structures; therefore, ultrasound is used to sterilize food and disinfect objects [5].

The purpose of our research was to develop a technology for cooked smoked lamb products with the study of low-frequency ultrasound effect on microorganisms - possible contaminants of meat raw materials.

The research tasks included:
- study of the low-frequency ultrasound effect on gram-positive and gram-negative spore-forming and non-spore-forming bacteria, as well as yeast-like fungi;
- sensory evaluation of the ready-to-eat product, processed at ultrasound exposure of 3, 6, 9 and 12 hours;
- development of technology for cooked smoked lamb products using ultrasonic salting.

2. Materials and methods

The studies were carried out on UOM - 2 equipment (35 kHz) and using an ultrasonic submersible emitter (26 kHz).

The effect of ultrasound on 4 types of bacteria: *Candida albicans*, *Eshericha coli*, *Bacillus subbillis*, *Staphylococcus aureus*, has been studied. The exposure ranged from 10 seconds to 10 minutes at a frequency of 35 and 26 kHz, an intensity of 1 W/cm².

Chilled mutton hip meat (M = 300 ± 50 g) was used for salting. The brine had the following composition: table salt - 13%, sugar - 0.15%, sodium nitrite - 0.075%.

The technological process was carried out in the Educational-Scientific-Industrial Complex "Pishchevik", microbiological studies were carried out in the microbiological laboratory of the Faculty of Veterinary Medicine, Food and Biotechnology of Saratov State Agrarian University.

3. Results and discussions

To study the possible bactericidal effect on ultrasonic treated microorganisms, a comparative assessment of the microbiological parameters of the treated and untreated contaminated with bacteria tap water was carried out. Daily cultures of the tested microorganisms were emulsified in sterile saline according to a McFarland turbidity standard of 10 IU. Then the suspension was ultrasonicated at different frequencies with different exposure. Thereafter 0.2 ml of the sonicated and untreated suspension was plated on beef-extract agar (*E. coli*, *B. subbillis*, *S. Aureus*) and Sabouraud agar (*C. albicans*) with a spreader. The inoculated media were cultivated at 37°C for 48 hours and the growing colonies were counted with subsequent recalculation of CFU/ml. Unsounded microorganisms’ suspensions was used as a control for calculating the relative suppressive effect, their growth rate was taken as 100%.

The results of our research revealed that at when ultrasound frequency of 35 kHz and treatment for up to 2 minutes, a slight microorganism’s suppression effect was observed, with an exposure for more than 2 minutes, a significant tendency towards a decrease in the relative intensity of their growth was manifested. When processing with ultrasound at 26 kHz, there was a decrease in the microorganisms’ growth rate already since 0.5 - 1 minute of treatment (fig. 1).

As illustrated in Figure 1, exposure to ultrasound at 35 kHz for 2 minutes inhibited the growth of *C. albicans* by 33.3%, *E. coli* - by 43.8%, *B. subbillis* - by 46.8%, *S. aureus* - by 80.6% in comparison with the that of control samples. At a treatment frequency of 35 kHz, with an increase in the treatment time, the growth rate of the studied bacteria decreased in comparison with that of the control. However, it was not possible to achieve total sterility. After sonication at 26 kHz and exposure for 1 minute, the growth rate of *C. albicans* decreased by 50%, *E. coli* - by 64.6%, *B. subbillis* - by 89.1%, *S. aureus* - by 86.8% in comparison with that of control samples.

Based on the obtained data, it can be concluded that reducing the ultrasound frequency has a better
bactericidal effect. Processing time has also affected the microorganisms’ growth. Treatment of 26 kHz for 10 minutes did not have a 100% bactericidal effect, but the microorganisms’ growth rate decreased by 90-98%.

![Figure 1. The microorganisms growth rate under different sonication conditions.](image1)

To assess the quality of the ready-to-eat product, an organoleptic assessment of cooked smoked lamb delicacy was made after 6, 8, 10 and 12 hours of ultrasonic salting. The evaluation of the ready-to-eat product was carried out using the quality assessment method according to the control sample, which is based on a comparison of the test samples properties with the control sample properties. The assessment was expressed in points using a 5-point scale for each of the determined parameters. According to all organoleptic parameters, the cooked smoked gourmet product after 12 hours of salting had the best indicators. According to a comprehensive quality assessment, the control sample had 4.98 points, the sample with a 12-hour salting - 5 points (Fig. 2).

![Figure 2. Profilogram of the organoleptic evaluation of a cooked smoked gourmet product.](image2)
To develop the technology of cooked smoked lamb products using ultrasonic treatment, a series of experiments was carried out to determine the influence of the intensity and exposure time of ultrasonication on the muscle fiber morphological parameters and on the raw materials physicochemical properties during salting [2].

Taking into account the data on the ultrasound bactericidal effect, the organoleptic assessment of the ready-to-eat product according to salting time and based on previously published results on the morphological and physicochemical properties of raw materials under different sonication conditions, a technology for cooked smoked lamb products was developed (fig. 3).

Acceptance of raw materials (chilled lamb pH - 5.7-6.3)
Deboning, trimming, pieces making (m = 400 – 500 g)
Brine preparation (density - 1100 kg / cm³: sodium nitrite - 0.075%, sugar - 0.15%, table salt - 13%).
Ultrasonic salting - 12 hours at a frequency of 26 kHz, an intensity of 1 W/cm² with a change of brine every 3 hours
Heat treatment:
drying - 30 - 40 min at t = 50°C
smoking - 3 hours at t = 30-50°C
cooking - 15 minutes at t = 85-90°C
Cooling to t = 8°C
Storage + (4-8°C)

**Figure 3.** Technological scheme for the cooked smoked lamb gourmet production.

Our studies have shown the advisability of low-frequency ultrasound using when lamb salting, since it has pronounced bactericidal properties, improves the brine penetration into the muscles and reduces the preparation time for raw materials. The best results for all of the parameters were obtained using ultrasound with a frequency of 26 kHz. The developed technology for the smoked cooked lamb products makes it possible to produce in a short time a delicacy that is superior in taste to traditional gourmet products.

4. **Conclusion**
Our data correlates with the results of a number of researchers who showed that using ultrasound in the food industry helps to reduce losses and prevent product spoilage [6]. Ultrasonic technologies have a number of advantages, such as process acceleration, increasing the efficiency, improving product quality or preserving its characteristics (texture, nutritional value, organoleptic properties), increasing food preservation [7]. Ultrasound is used in various technological processes (filtration, freezing, thawing, salting, sterilization / pasteurization, slicing) [8] for various food products (meat, fruits and vegetables, cereals, dairy products) [9].

Thus, the developed scheme of smoked cooked lamb delicacies helps to improve the sanitary condition of the raw meat salting process, accelerate the product yield and improve the organoleptic properties of lamb delicacies.

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