Physical and chemical effects of ultrasonic cavitation on the grain of meat when lamb salting

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Abstract. The data of a study of the influence of ultrasonic lamb salting on the grain of meat raw materials are presented. It has been established, that at ultrasonic salting with a frequency of 35 kHz, structural damage and turgescence of muscle fibers, as well as local destruction of the sarcolemma with the pronounced rugosity are observed, besides the cross-striation is poorly expressed, and the tissue structure is disturbed. An ultrasonic lamb salting with a frequency of 26 kHz is attended by an increase in quantity of crevices and transverse microcracks, loosening up of muscle fibers, formation of cavities between them while maintaining muscle tissue structure, which facilitates the penetration of brine between and inside the muscle fibers. It allows us to recommend ultrasonic treatment at a frequency of 26 kHz for activation of the brine to intensify the technological process wet of lamb salting.

1. Introduction

Recently, ultrasound has been increasingly used in various sectors of the national economy. The use of ultrasound in the food and agricultural processing industry is of considerable interest from the point of view of its influence on the physical and chemical parameters of raw materials and the safety of finished products. Ultrasound is used for pre-treatment of agricultural raw materials [1], and in the technological process of food production, in particular when salting [2]. A number of authors note that the passive transport of brine components is carried out mainly through the tissue intercellular space, and the use of cavitation-activated brines contributes to the intensification of the technological process, especially when salting large-sized meat products, and improving the consumer properties of finished products [3, 4]. Moreover, the essential amino acid content, the essential amino acid/non-essential ratios and content of volatile flavor substances are significantly increased with the ultrasound treatment of meat raw, which has a positive effect on chemical profiles of spiced meat taste and flavor [5]. There is evidence in the academic literature that the effect of ultrasonic cavitation on the raw materials physicochemical properties is due to its effect on the morphological meat characteristics. The lipids oxidation rate significantly increases during ultrasound processing in comparison with static brine, protein aggregation grows up, which led to an increase in free sulfhydryl residues and, as a consequence, hydrophobicity of
the protein surface. Ultrasonic salting leads to changes in the structure and oxidation of meat proteins, which is caused by the mechanical effect of cavitation and as a result, free radicals formation [6].

The aim of our research was to study the effect of ultrasonic treatment on the microstructure of muscle tissue when wet lamb salting.

2. Materials and methods
Isolated from the hip, cooled lamb meat with natural autolysis process was used. The mass of the pieces was 300 ± 50 grams (n = 6). Ultrasound meat salting was carried out with using of the “PSB-Gals” device (Russia) with an ultrasonic frequency of 35 kHz and an ultrasound intensity of 1 W/cm² (figure 1a), and an ultrasonic immersion emitter with an ultrasonic frequency of 26 kHz and an ultrasound intensity of 1 W/cm² (figure 1b) for 5 hours. The brine contained sodium chloride (7%), sugar (1.5%) and sodium nitrite (0.015%). The density of the brine was 1050 kg / m³.

![Figure 1. Ultrasonic devices: a - "PSB - Gals", b - submersible emitter.](image)

To study the effect of ultrasound on the microstructure of muscle tissue, histological studies were performed. Pieces of meat 0.5 x 1 cm from different parts of the sample were cut along the muscle fiber and fixed in a 10% aqueous solution of neutral formalin for 48 hours (after a day, the formalin solution was replaced with freshly prepared). Then the samples were removed from the fixing solution and washed with running water for a day. Dehydration of samples and paraffin embedding were performed according to standard methods [7]. Slices of 7 μm were made using a sledge microtome MS-2 (Russia). Then, after dewaxing, they were stained with Ehrlich hematoxylin and eosin, followed by microscopy [7].

3. Results and discussions
The results of comparative analysis of samples histological studies are presented in figures 2-4.

![Figure 2. Lamb. The natural autolysis process. Ehrlich hematoxylin and eosin staining. × 300.](image)
The morphological features of raw lamb with the natural autolysis process (figure 2) include the rectilinear-wavy muscle fibers arrangement the appearance of transverse ragged cracks. There are small free spaces between the muscle fibers. The nuclei of myocytes are clearly contoured, flattened-oval, located under the sarcolemma, which is typical for raw meat.

Figure 3. Lamb. Salting 35 kHz, 1 W/cm² 5 hours. Ehrlich hematoxylin and eosin staining. × 300.

Destruction of muscle fibers and local sarcolemma destruction are observed at ultrasonic salting with a frequency of 35 kHz (figure 3). The sarcolemma rugosity is clearly expressed, and the cross-striation is low-grade, muscle fibers are swelling. Dissociation and loosening of muscle fibers with the appearance of cavities between them is noticeable.

Figure 4. Lamb. Salting 26 kHz, 1 W/cm² 5 hours. Ehrlich hematoxylin and eosin staining. × 300.

Pronounced disfoliation of muscle fibers with appearance of large cavities between them is observed at ultrasonic salting with a frequency of 26 kHz (figure 4). The processes of muscle fibers destruction and local destruction of sarcolemma are enhanced. Number of transverse microcracks and cracks, loosening and fragmentation of muscle fibers are increased, and wide cavities are appeared between them. However, the tissue structure and the grain orientation are still preserved.

4. Conclusion
The results of our research allow us to conclude that the use of low-frequency ultrasound in the salting process accompanies increasing of transverse microcracks and cracks number in the muscle fibers, leading to their fragmentation. Along with the destruction of muscle fibers, local destruction of the sarcolemma occurs. These processes promote the penetration of brine between the muscle fibers and accelerate the diffusion of salt into the fibers. It should be noted that ultrasonic cavitation at 26 kHz has a less destructive effect on the muscle tissue, which is important for the organoleptic properties of the finished product and can affect its safety.
Our data coincide with the opinion of a number of authors. According to D C Kang et al (2016) data, a positive effect on the oxidation rate and protein structure of meat has a wet ultrasound salting at a frequency of 20 kHz [6]. T L Barretto et al (2018) report that use of ultrasound during salting reduces the total liquid elimination and increased the density of raw materials, which has a positive effect on the physical and chemical properties, microstructure, and sensory perception of finished product [8].

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