Intensification of lamb salting process with low frequency ultrasound

E S Krasnikova¹, N L Morgunova², A V Krasnikov¹, A S Rykhlov², V A Babushkin¹ and M I Sukharev¹

¹ Michurinsk State Agrarian University, 101, Internationnaya Street, Michurinsk, 393760, Russia
² Saratov State Vavilov Agrarian University, 1, Teatralnaya Square, Saratov, 410012, Russia

E-mail: krasnikovaes77@yandex.ru

Abstract. Young lamb has high nutritional properties due to its high protein, amino acids, vitamins and microelements content. However, the specific odor and the high fat pour point are the main obstacles to the industrial use of lamb. The purpose of our research was to study the physical and chemical characteristics of raw lamb after ultrasonic salting and to select the optimal processing conditions and their economic justification. Experimental samples were salted in the devices UOM - 2 and PSB - Gals at 35 kHz ultrasound frequency, as well as using an ultrasonic submersible emitter at 26 kHz. Ultrasound treatment has led to an increase in the pH and moisture content of the raw material, as well as in product yield. With an increase in the salting time, the water activity (Aw) decreased. Based on the results of physicochemical samples studies and comparative analysis of the economic efficiency, a submersible ultrasonic emitter with an ultrasonic frequency of 26 kHz and a salting duration of 12 hours was recommended for lamb delicacies salting.

1. Introduction

Proteins, which are necessary for a living organism, have a special role in nutrition. The most complete proteins are proteins of animal origin. Lamb ranks a special place among meat products. Young lamb has high nutritional properties due to its high content of protein, amino acids, vitamins and microelements.

However, there is no industrial processing and production of lamb products in Russia. The specific odor due to the presence of hirsic acid and the high fat pour point are the main obstacles to the industrial use of lamb. Modern technologies for the lamb delicacies preparation are not profitable due to the long meat salting. Duration of exposure of hams in brine at a temperature of 2-4°C is 10-12 days, brisket - 2-3 days. Therefore, for the lamb foodstuffs production for a wide range of the population, scientifically based technologies are necessary to reduce the time for delicacy preparing.

Modern methods of meat salting intensifying are widely used in food industry. Among them are mechanical, thermal- and hydrophysical, electrical and electromagnetic, biochemical and acoustic. The most popular ones are combined salting methods, when the raw material is subjected to extrusion with brine with further mechanical processing [1].

Ultrasound is widely used in the food and processing industry to activate and deactivate biological processes [2, 3]. Ultrasound causes cavitation effects, which accelerate the dissolution of the salting...
ingredients in the brine. The effect of ultrasound on a liquid medium helps to reduce the coefficient of dynamic liquid viscosity, enhances the micro flows turbulization [4]. Ultrasonic treatment reduces salting time up to 2.5 - 3 times [5]. Ultrasonic salting increases the muscle fiber permeability to brine ingredients, however, destruction of myofibrils can be observed [6]. Therefore, it is necessary to select the optimal ultrasound parameters for salting.

Research on the effect of ultrasound on biological objects is being carried out all over the world. The high possibilities of using ultrasound in food technology are undeniable [7, 8].

The purpose of our research is to study the physical and chemical characteristics of raw raw lamb after ultrasonic salting and to select the optimal processing conditions and their economic justification.

2. Materials and methods
Chilled lamb hip was used for salting. The pieces mass was 300 ± 50 grams. Experimental studies were carried out using the devices UOM - 2 (V = 5.7 l) and PSB - Gals (V = 1.3 l) with an ultrasonic vibration frequency of 35 kHz, as well as an ultrasonic submersible emitter (V = 3.0 l) with an ultrasonic vibration frequency of 26 kHz at an ultrasound intensity of 1 W/cm² (fig. 1). The brine had a density of 1100 kg/cm³ and included sodium nitrite 0.075%, sugar 0.15% and table salt 13%. Lamb salting was carried out during 6, 8, 10 and 12 hours.

To calculate the economic justification, cooked smoked gourmet products were taken as a control sample according to TU 10.13.14-095-37676459-2016 Delicacy meat products. To calculate the total cost of the control and prototype samples, we took into account the average market prices of production costs and costs associated with their realization.

3. Results and discussions
The moisture content and the ability of proteins to retain it depend largely on the raw material pH level. The moisture binding capacity (MBC) of the raw material is expressed as a graph of function showing a direct correlation with the medium pH. BCC = f (pH). The Hamm diagram illustrating correlation between the muscle tissue moisture binding capacity and the pH value is shown in figure 2. The results of our research fully confirmed this correlation.
The data of physical and chemical studies of lamb meat samples under various conditions of ultrasonic salting are presented in table 1.

Table 1. Results of physical and chemical studies of samples

| Index                | Unprocessed raw materials | US salting 1h 35 kHz | US salting 1.5h 35 kHz | US salting 1.5h 35 kHz | US salting 3h 26 kHz |
|----------------------|---------------------------|----------------------|------------------------|------------------------|----------------------|
| pH                   | 6.37±0.011                | 6.60±0.028           | 6.94±0.009             | 6.97±0.15              | 7.03±0.043           |
| MBC, %               | 96.85±0.28                | 95.68±0.65           | 93.24±0.75             | 86.58±0.65             | 83.18±0.31           |
| Moisture, %          | 70.17±0.04                | 72.65±0.04           | 75.78±0.04             | 75.10±0.04             | 74.03±0.04           |
| Aw                   | 0.9864±0.0011             | 0.9755±0.0009        | 0.9743±0.0013          | 0.9692±0.001           | 0.9649±0.0012        |
| Product yield, %     | -                         | 105.5                | 112.24                 | 106.02                 | 108.37               |

The pH measurement of muscle tissue aqueous extracts in control and experimental samples revealed an increase in acidity. The change in pH is possibly associated with the activation of the brine and its intense penetration into the test samples.

The moisture content of the meat increased from 70.17 to 75.78 % when processed in the UOM - 2 device for 1 hour and 1.5 hours, respectively. When salting in an ultrasonic device "PSB-Hals" for 3 hours, the moisture content of the meat was 75.1 %, and when salting for 3 hours using a submersible transducer, the moisture content was 74.03 %.

When controlling the change in the studied samples mass before and after salting, a tendency to an increase in the yield of salted raw materials was revealed, depending on the frequency of ultrasound and the salting time. An ultrasound frequency of 35 kHz gave the highest product yield with an increase in the duration of the salting, but the frequent change of the brine (every 30 minutes) was an obstacle to the salting of gourmet products. The ultrasonic frequency of 26 kHz for 3 hours of salting allowed increasing the mass by 8.37 %.

In general, with an increase in the salting time, the water activity (Aw) decreased. The meat and meat products storage time, the color and smell formation, as well as losses during heat treatment and storage depend on the amount of water activity. Moreover, the Aw is lower, the product quality indicators are higher [9].
With an increase in the salting time, such indicators as water activity and the content of bound moisture decreased. When salting with an ultrasound frequency of 35 kHz, the temperature of the brine rose to 10°C in 30 minutes, which required frequent changes of the brine. When the raw materials were salted at a frequency of 26 kHz, the brine was changed only every 3 hours.

The sonicated meat samples were cooked at 80-90°C until done and viewed on the cut to assess salting uniformity. Treated with ultrasound at 26 kHz samples had the best performance. On the cut, the pieces were evenly colored, without gray spots, which proves the uniformity of the salting. Studies have shown the feasibility of low-frequency ultrasound using when salting lamb. Based on the experimental data results, a submersible ultrasonic emitter with an ultrasonic frequency of 26 kHz and a salting duration of 12 hours was recommended for lamb delicacies salting.

A comparative analysis of the economic efficiency of the gourmet products production was carried out according to the standard method [10]. The calculation results are presented in Table 2.

| Table 2. Results of economic efficiency comparative analysis (1 kg) |
|---------------------------------------------------------------|
| Description of costs | Control sample, rub | Prototype sample, rub |
| Raw and basic materials cost | 250.000 | 250.000 |
| Transport tax | 12.500 | 12.500 |
| Supporting materials | 10.920 | 72.800 |
| Supporting materials | 0.910 | 0.840 |
| Fuel and electricity | 1.200 | 0.800 |
| Remuneration | 3.120 | 3.120 |
| Unified social tax | 0.204 | 0.136 |
| Personal Injury tax | 27.880 | 27.470 |
| Other expenses | 6.130 | 6.060 |
| Non-production expenses | 62.570 | 61.760 |
| Overheads | 37.543 | 37.061 |
| Total cost | 56.310 | 55.590 |
| Dividend | 484.210 | 478.180 |
| Selling price | 654.300 | 629.200 |
| Transfer prices | 250.000 | 250.000 |

As it follows from the presented data in table 2, the selling price of 1 kg of the prototype sample was 25.1 rubles less than the selling price of 1 kg of the control sample. At the same time, the dividend from realisation of produced with ultrasound delicacy product is 6.03 rubles more than from the control sample realisation.

4. Conclusion
Thus, the results of our research demonstrate that ultrasound with a frequency of 26 kHz at an intensity of 1 W/cm² and a salting time of 12 hours contributes to the production of a halfway product with better physicochemical properties. The calculation of the economic efficiency of the lamb delicacies production showed that the selling price of 1 kg of the prototype sample is 25.1 rubles cheaper than that of the control sample. Our data allow us to recommend the developed method of raw materials salting for the lamb delicacies production.

5. Acknowledgments
The authors are deeply grateful to the collective of Educational-Scientific-Industrial Complex "Pishchevik" of the Saratov State Agrarian University named after N.I. Vavilov for the provided equipment. In addition, we are very grateful to the professor of the department "Food technology", doctor of technical science, Professor Rudik Felks Yakovlevich for methodological assistance.
References

[1] Zou Y, Yang H, Zhang M, Zhang X, Xu W and Wang D 2019 *Asian-Australas J Anim Sci.* 32(10) 1611–20

[2] Krasnikova E S, Babushkin V A, Morgunova N L and Krasnikov A V 2020 *J. Phys.: Conf. Ser.* 1679 022002

[3] Rudik F Ya, Morgunova N L and Krasnikova E S 2020 *IOP Conf. Ser.: Earth Environ. Sci.* 421 022022

[4] Bhargava N, Mor R S, Kumar K and Sharanagat V S 2021 *Ultrason Sonochem* 70 105293

[5] Alarcon-Rojo A D, Janacua H, Rodriguez J C, Paniwnyk L and Mason T J 2015 *Meat Science* 107 86-93

[6] Krasnikova E S, Morgunova N L, Krasnikov A V, Akchurin S V and Akchurina I V 2020 *J. Phys.: Conf. Ser.* 1679 022001

[7] Zhang F, Zhao H, Cao Ch, Kong B, Xia X and Liu Q 2021 *Ultrason Sonochem* 71 105379

[8] Li K, Kang Zh-L, Zou Y-F, Xu X-L and Zhou G-H 2015 *J. Food Sci. Technol.* 52(5) 2622–33

[9] Contreras-Lopez G, Carnero-Hernandez A, Huerta-Jimenez M, Alarcon-Rojo A D, Garcia-Galicia I and Carrillo-López L M 2020 *Food Sci. Nutr.* 8(2) 786–95

[10] Chaldaeva L A 2015 *Enterprise Economics: textbook and workshop for academic undergraduate* 435 p