EFFECT OF ULTRASONICALLY ASSISTED THAWING ON CHICKEN BROILER MEAT

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Abstract—**The objectives of this study were to investigate the variation of physicochemical properties of chicken broiler meat thawed with low frequency and medium intensity ultrasound. The studies were conducted on breast muscles (m.pectoralis) without the skin of cooled carcasses of broiler chicken 24 hours after the slaughter. The following were studied: pH, water absorbance of meat, content of free water, chemical composition, redox potential, parameters of texture and colour of meat. Sonication of meat was performed in a tub device with the capacity of 1 dm³ using ultrasounds with the frequency of 40 kHz and the source intensity of 2.5 W·cm^{-2}. Results of this study suggest that ultrasonically assisted thawing had effect on thaw loss and heating loss of broiler chicken breast meat. High intensity treatment during meat thawing causes higher losses. Results of the experiment show the possibility of reducing thaw loss and heating loss but additional investigations are necessary. The pH, Warner-Bratzler shear force of meta thawed with ultrasound are lower and ORP, colour parameters (CIE L*a*b*) are higher compared with traditionally thawed sample. The method of immersion thawing of meat and others foods is very promising but it should be optimized and analyzed for safety of the treated food.**

Index Terms—**thawing, ultrasound, chicken broiler meat.**

I. INTRODUCTION

Freezing is a well known preservation method widely used in the meat industry. At temperatures lower than -10°C chemical reaction rates are greatly reduced and the activity of a few microorganisms is decreased. Meat technologists are interested in developing the freezing processes and the necessary equipment for effective and rational processing due to minimization of the energy requirement, safety and quality of the meat.

One of the new trends in meat processing is using the power ultrasound for freezing and thawing. Resulting from the acoustic effects, the application of power ultrasound is beneficial to many food-freezing processes (Zheng & Sun, 2006). Ultrasound energy is associated with acoustic waves at the frequency of above 20 kHz that are able to travel through liquids, solids and gases. High frequency and low intensity ultrasound is used in diagnostic sonography, therapy, sonomicroscopy, in navigation and ranging, material testing, measuring of fat thickness in living animals and others (Sigfusson, Ziegler & Coupland, 2004; Dolatowski, Stadnik & Stasiak, 2007). A lower frequency and a higher intensity of ultrasound are useful in varying the properties of different materials. Ultrasound treatment causes physical and chemical alternations in the materials being processed. The waves pass through a liquid producing bubbles or cavities. The effects of collapsing are local extremely high shock waves, high temperatures and pressures. The sonochemical reactions, sonoluminescency, cell disruption, heat and mass transfer are the effects of cavitation. Critical factors are the frequency and intensity of the ultrasound, the time of exposition, the initial physical and chemical properties of material, its temperature, the environment pressure, the variability of treated material and others. The influence of the factors of ultrasound on naturally labile properties of meat is an issue in laboratory investigations. Ultrasound has been useful to increase salt diffusion in meat injected with brine (Dolatowski 1988), to accelerate meat ageing, meat tenderizing (Dolatowski, Smarkusz & Stasiak, 1995; Got, Culioli, Berge, Vignon, Astruc, Quideau & Lethicq, 1999; Dolatowski, Stasiak & Latoch, 2000), to inactivate microbes (Piyasena, Mohareb & McKellar, 2003; Kordowska-Wiater, Pomorska & Stasiak, 2009), and in crystallization of fats. Because of its physical effects, especially dissipation observed in materials, medium intensity and low frequency ultrasound has been proposed to assist thawing. Therefore, the objectives of this study were to investigate various physicochemical properties of chicken broiler meat thawed with low frequency and medium intensity ultrasound assist.

II. MATERIALS AND METHODS

The studies were conducted on breast muscles (*m. pectoralis*) without the skin of cooled carcasses of broiler chicken 24 hours after the slaughter. The following were studied: pH, water absorbance of meat, content of free water, chemical

composition, redox potential (ORP), parameters of texture and colour of meat. Sonication of meat was performed in a tub device with the capacity of 1 dm3 using ultrasounds with the frequency of 40 kHz and the source intensity of 2.5 $W \cdot cm^{-2}$. Meat samples with the weight of 200±15 g were packed in PE foil bags PE (60 μm) and they were hermetically closed after removing the air from the inside. Meat samples were immediately frozen and stored for 7 days in a freezer chamber with mechanical circulation of the air with the temperature of -24°C. The samples were defrosted in a liquid with the temperature of 5°C±1°C (sample S0) till the temperature of -2°C±1°C in the geometrical centre of the sample. Thawing in the liquid was accompanied by sonication lasting 10% (sample S1), 50% (sample S2) or 100% (sample S3) of the total thawing time. Next, the samples were thawed at the temperature of 4°C. The total thawing time was 24 hours. Studies were carried out on pH, water absorbance of meat, water content , chemical composition, redox potential, size of drip while thawing and heat processing, parameters of texture and colour. pH was measured on homogenates prepared from 10 g of meat in 100 ml of water using a pH-meter (CPC-501 Elmetron). Meat water absorbance was calculated on the basis of the amount of the drip after the whirling (3000g, 10 min) of the homogenate prepared from 100 g of meat in 200 ml of water. The content of free water was established using the indirect method by Grau and Hamm (1953). The fat content was determined using the extraction method by Soxhlet. The content of water was established on the basis of the mass of meat samples subjected to drying at the temperature of 105°C. The activity of the water of the meat surface was marked using the device of LabMaster aw (Novasina). The redox potential was established using a pH-meter and a platinum electrode (CPC-501 & ERPt-13 Elmetron) (Ahn & Nam 2004). The measurement of the temperature was made by means of a multi-channel register MPI-L Metronic and thermoelements NiCr-NiAl (200K, Czaki). The weight losses were determined of meat samples hermetically closed in PS foil bags and heated in water with the temperatures of 60°C, 70°C and 80°C for 20 min. Parameters of colour CIE L*a*b* of the surface and the cross-section of the sample were determined by means of a spectrophotometer X-Rite 8000 series with a standard illuminator D65/10° and aperture size 8 mm. Parameters of texture were determined using a texturometer TA.XT.plus Stable Microsystems. The Warner-Bratzler shear test was made using an add-on device DP/90+DHP/WBV. The speed of the head translocation during the test was 2 mm/min. Cylindrical samples with the diameter of 20 mm were subjected to tests. An analysis was made of the maximum force and work of the shear using the program Texture Exponent Stable Microsystems.

III. RESULTS AND DISCUSSION

Results of studies on the chemical composition showed that the initial mean amount of water in the research material was 73.1±0.3% while the content of fat was 2.81±0.02% (tab. 1). The biggest amount of free water (17.4%) in thawed meat was found in sample S3 subjected to the most intensive sonication. Water activity of the studied meat was within the range 0.994-0.999 and was slightly lower after ultrasound processing. Sonication while thawing had a significant effect on the decrease of pH value of sample S3 (by 0.13) and an increase of ORP by 22 mV.

Table 1. Chemical composition, water activity, pH, oxidation reduction potential (ORP) and thaw loss

Parameter	CO	S0	S1	S2	S3
Fat (%)	2,81	-	-	-	-
Water (%)	73,1	-	-	-	-
Free water (%)	12,6	13,7	15,5	16,9	17,4
Water activity (a_w)	0,999	0,999	0,998	0,996	0,994
pH	5,66	5,82	5,5,78	5,72	5,69
ORP (mV)	27	56	57	58	78
Thaw loss (%)	-	6,2	4,9	4,7	8,7

It was found out that sonication while thawing caused a decrease of the losses. Losses lower than in the control S0 were observed in the case of samples S1 – 4.9% and S2 – 4.7%. Sample S3 showed the highest level of losses – 8.7%.

It was found out that while thawing, samples subjected to the effect of ultrasounds are characterized by significantly lower values of the shear force (tab.2). The lowest shear force, i.e. 21.0 N was shown by sample S3 and it was lower by 15.7% as compared to the control (S0). The studies also observed a higher value of the shear force of meat subjected to sonication.

Table 2. Warner-Bratzler shear force and energy

Parameter	CO	S0	S1	S2	S3
Max shear force (N)	27,8	24,9	24,7	22,2	21,0
Energy (mJ)	164,7	99,9	103,4	124,1	117,4

Results of studies of the parameters of the colour of meat thawed by means of ultrasounds showed a higher value of lightness L* and components a* and b*. Sample S3 showed the biggest difference of lightness as compared to the control sample (S0). Its lightness L* was higher by 5.16, redness a* by 2.49 and yellowness by 0.95. A complete

change of colour ΔE* of sample S3 in relation to sample CO is characterized by the highest value of 6.21. A complete change of colour ΔE* of sample S1 was 2.01 and sample S2 – 2.93.

Table 3. Instrumental colour characteristics CIE L*a*b* and ΔE*

Parameter	CO	S0	S1	S2	S3
L*	58,63	58,54	59,34	60,24	63,70
a*	-1,00	-0,48	0,24	1,13	2,01
b*	8,02	9,02	9,44	9,23	9,97
ΔE*	0	1,13	2,01	2,93	6,21

It was found out that while heating the meat thawed by means of ultrasounds (samples S1, S2, S3), bigger effluents are observed as compared to the control sample S0. The size of the drip increased together with the increased of the intensity of the effect of ultrasounds, reaching the maximum value of 12.8% at the temperature of 60°C and 31.2% at the temperature of 80°C.

Table 4. Heating loss (mean ± standard deviation)

Temperature	S0	S1	S2	S3
60°C	8,4±0,8	9,7±1,1	12,1±0,8	12,8±1,5
80°C	27,4±1,2	27,9±1,3	30,1±0,9	31,2±1,6

As observed before, the thawing drip from sonicated meat was lower as compared to the control sample. At the same time, it was found out that the size of the drip while heating at the temperatures of 60°C and 80°C was higher. The total drip from meat while thawing and while heating is presented in figure 1. The sum of drips from sample S3 is the highest. The amount of drips from samples S1 and S2 are comparable with the amount of drip from the control sample S0. Following thawing and heating, samples S3 lost, on average, 17.0% at the temperature 60°C and 28.9% at 80°C. On the other hand, sample S1 showed the total loss of liquid smaller by 0.3% after thawing and heating to 60°C,and smaller by 0.6% after heating to 80°C.

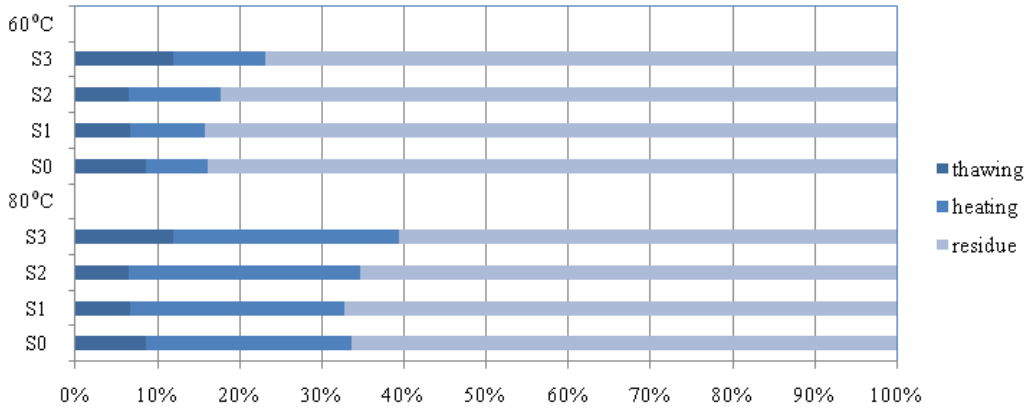

Figure 1. Comparison of liquid loss of thawed and heated meat

Results of Pohlman, Dikeman & Kropf (1997) investigations suggest that ultrasound exposure had little effect on shear and cooking characteristics of beef meat due to high connective tissue. Ultrasound treatment in some instances tended to improve shear properties of fresh muscle. Pohlman et al. (1997) showed that convection heating after ultrasound exposure significantly increases cooking losses, although ultrasound treatment in some instances tends to decrease the losses. They showed that color characteristics of beef vary after ultrasound exposure. Muscles became lighter (L*) in color and less red (a*) and more yellow (b*). Results Tang, Faustman, Mancini Seyfert & Hunt (2006) investigations show that sonication treatment had the potential to affect Mb stability via mitochondrial lipid oxidation and MetMb reduction. Despite the low content of protein responsible for red meat color in the chicken meat the changes of parameters of colour are described. Studies of Ngapo, Babare, Reynolds & Mawson (1999) show the combined effects of freezing rates, frozen storage and thawing rates on crystal formation and the ulstrastructure of pork sample. Thawing with ultrasound treatment varies the standard conditions to special with presence of phenomena like cavitation, dissipation, microstreaming, mass transfer in meat. Roncalés, Ceña, Beltrán & Jaime (1993) investigations suggest that ultrasonication released lysosmal enzymes from liver cells while cell membranes suffered little damage. Ultrasonic treatment of muscle fiberes enhanced proteolytic activity and increased intensity of its degradation. Results of Pohlman et al. (1997) study of the texture of beef show the higher peak force and its work after ultrasound treatment. Got et al. (1999) confirm ultrasound ability to increase beef tenderness. The pH value of beef several hours after

slaughter is increased by ultrasound. The decrease of pH of chicken meat after treatment may be a result of higher proteolysis, freezing and thawing. The work of Jayasooriya, Torley, D'Arcy & Bhandari (2007) shows that pH generally increased with increasing ageing and ultrasound treatment. They showed the 15-30°C increase in meat temperature depending on the length of ultrasound treatment with sonotrode. The heating could distort the image of changes of meat properties. Another studies of Stasiak & Dolatowski (2001) and Jayasooriya et al. (2007) confirm decreasing the shear force and hardness of beef after ultrasound treatment but they saw no increase in drip and total loss, and on any of the colour parameters. Miles, Morley & Rendell (1999) show acceptable ultrasonic thawing results, however they suggest higher frequencies of ultrasound due to direct contact and heating of treated samples. The heating is eliminated for immersion coupling used in the experiment.

IV. CONCLUSION

Results of this study suggest that ultrasonically assisted thawing had an effect on thaw loss and heating loss of broiler chicken breast meat. High intensity treatment during meet thawing causes higher losses. The results of experiment show the possibility of reduction of thaw loss and heating loss but additional investigations are necessary. The pH, Warner-Bratzler sherar forces of meat thawed with ultrasound are lower and ORP, colour parameters (CIE L*a*b*) are higher compared with traditionally thawed sample. The method of immersion thawing of meat and others foods is very promising but it should be optimized and analyzed for the safety of the treated food.

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