VARIATIONS OF MECHANICAL PROPERTIES OF THE MEAT AS A RESULT OF ULTRASONIC MASSAGING

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Introduction

The application of ultrasounds in many branches of medicine and industry is more and more popular (3,5). One of the reasons of growing utility of ultrasounds is the multiplicity of effects combined with the propagation of the waves - they may be used both for the process monitoring and for the effecting the physical and chemical properties of bodies subjected to that kind of waves. The components of substances placed in an ultrasonic field may be degradated and depolimerized but also may be converted into new and sophisticated chemical compounds. The course of those phenomena depends on factors influenced by the field parameters and on initial properties of bodies placed in such a field. So that the following factors may effect: kind of the source of ultrasonic waves, frequency, sound level, acoustic feedback efficiency, physical structure and chemical composition of the body etc. The range of ultrasound action on biological materials like meat is very wide and the phenomena occurring under action of ultrasounds are hard to evaluate due to their complicated character (3,5). This is caused by a characteristic structure of muscle tissue, very dynamic changes occurring in it and properties of ultrasonic field arising in such kinds of biological materials. The ultrasonic waves propagating in various objects may, depending of their parameters and physical properties of those objects, be subjected to various occurrences like reflection, refraction, dispersion or energetic transformations causing the damping. The intensity of those particular occurrences depends both on source parameters of ultrasonic waves and parameters of the body the ultrasonic fields exists in (5). The aim of researches described below was to know the variation range of mechanical properties of raw meat during massaging by ultrasounds.

Methods

The studies of variation of mechanical properties of meat have been performed on *musculus semimembranosus* taken from pig carcasses of uniform quality. The studies were of comparative nature. The test samples were taken from left halves and the control samples from the right ones. The meat of PSE and DFD characteristics was eliminated from further tests.

The muscle was injected in 15% and then massaged in an ultrasonic apparatus (1). The samples of about 50 kg total masses were massaged 24 and 48 hours after slaughtering. The meat was massaged three times with 24 hours storage breaks. The massaging lasted 20 minutes plus 3 minutes ultrasound treatment. The massaging time for control samples was 30 minutes each time.

The tests of variation of mechanical properties of meat during massaging were made by a penetrometric method (4) using a 6 mm diameter penetrator moving with 1 mm/sec velocity. The penetrator was sunk into a meat sample half-space perpendicularry to muscle fibres till the yield point was achieved (Fig.1). The tests and recordings were made on INSTRON 4302 equipment. The recorded stress runs were approximated by linear and power functions. The mathematical parameters of those functions were furtherly analysed.

Results

The structural and mechanical properties of meat depend on life factors, post-slaughtery changes and treatments applied. The changes of physical properties may be evaluated by various methods (2), however the penetrometric tests (2,4) are relatively simple and may characterize the speed of variation of mechanical properties of meat. The work of sinking the penetrator into the meat is combined with a complex elastic deformation generated mainly by a structural system of microfibrillic proteins and a plastic deformation caused by a hydratation. It may be assumed, and is was confirmed by tests, that the stresses recorded during penetration depend on the microfibrillic proteins structure and partially on compounds dissolved in sarcoplasma. The sarcoplasmatic compounds affect indirectly the microfibrillic structure and therefore the work of sinking the penetrator into the sample. It may be suggested that the form of penetrometric curves may be influenced also by sarcolemma proteins.

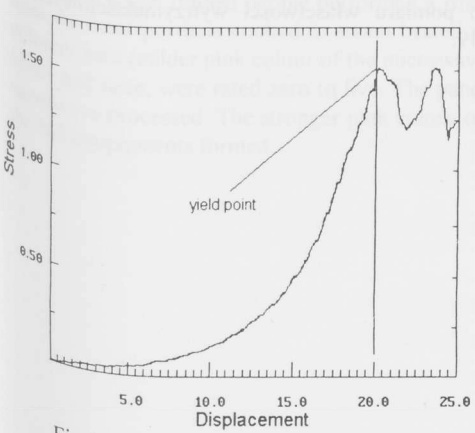

Fig.1. Sample penetrometrical curve

The penetrator sinking into a meat sample is combined with some irreversible effects destroying the structure of meat tissue. The stresses recorded during penetrometric tests reflected first of all the compression stressed generated in samples. Their values are quite well correlated with organoleptic tests of crispness and juicity of final products.

The penetrometric tests have shown (Fig.2) a crucial role of time gone between the slaughtering and time of ultrasonic treatment in variation of mechanical properties of meat during massaging. The values of *a* and *b* of mathematical equations approximating the recorded stress variations during sinking the penetrator as a function of its displacement have been statistically analysed (Fig.2). It has been shown, that the treatment started 24 hours after slaughtering had effected statistically much stronger than the one started 48 hour after slaughtering. The massaging cyclus started 24 hours after slaughtering induces much stronger changes (Fig.2) than the cyclus started 48 hours after slaughtering. The results of tests performed on pickled meat, have shown higher values of equation coefficients describing the empirical curves in relation to the results obtained on control samples. It may be supposed, that the first 30 minutes of massaging makes the meat more elastic.

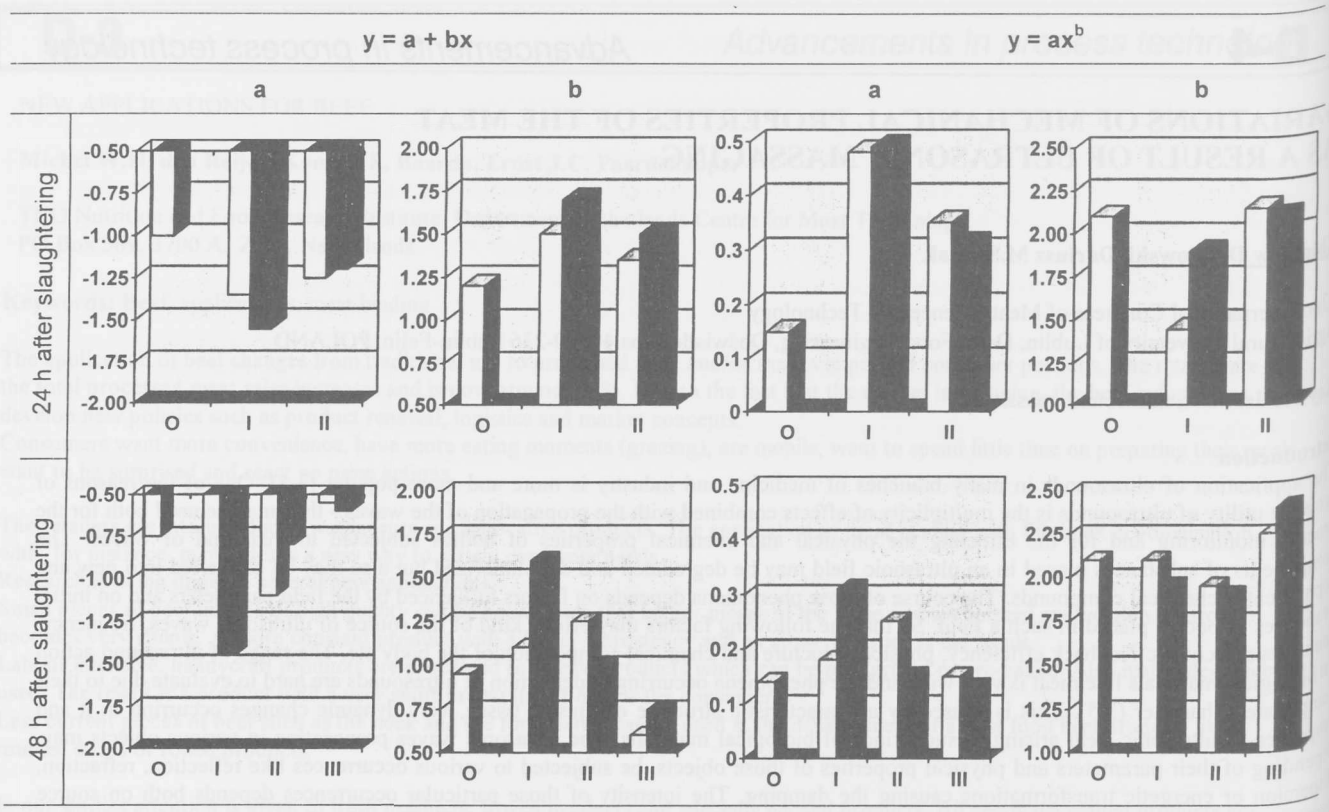

Fig.2. Changes of coefficients of function approximating the stress curves obtained in penetration tests during meat massaging. Legend: 0 - samples before massaging; I, II, III - samples after 1st, 2nd, 3rd massaging; □ - samples after massaging, □ - samples after ultrasound massaging.

Further massaging increases the plasticity of the meat, which is described by decreasing values of equation coefficients describing the curves after the second and the third massaging.

The relations between *a* and *b* coefficients of equations approximating the mechanical characteristic curves show, that the starting of massaging in the first stage of rigor-mortis causes, the compression of protein structures (b coefficient increases) and then, during further massaging, a substantial decreasing. The meat subjected to ultrasonic waves is getting more plastic compared to control samples. The test results show that the ultrasounds stimulate the rigor-mortis state and accelerate the destruction of protein structures of sarcomers.

The massaging time may be shortened if the ultrasonic massaging is started 48 hours after slaughtering. The action of ultrasonic waves is in that case very similar to mechanical massaging in a machine.

The researches have shown, that there is a possibility of shortening. The massaging time due to treatment by ultrasounds of relevant frequence and level. But the effectivity of the treatment depends on the mode of generating and transforming the mechanical energy to the meat during massaging.

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