EFFECT OF ELECTROSTIMULATION ON MICROSTRUCTURE OF MEAT

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SUMMARY: In order to investigate tissue, cellular and subcellular peculiarities of meat, placed after electrostimulation in chilling conditions for ageing, the structure of longissimus dorsi of steers was studied by means of light and electron microscopy methods.

Electrostimulation was performed 30-40 min post mortem, after skinning electrodes were applied in 2 sites: neck and roumd. Electric current with standard characteristics was used: voltage 220 V, frequency 25 Hz, duration - 120 seconds.

Structure of muscle tissue was investigated by light and electron-transmission microscopy. Material for study was taken immediately after electrostimulation and during ageing at 0°C, that lasted 24 hours. Longissimus dorsi of carcasses, which were not electrostimulated, served as controls.

It was established, that microstructure of electrostimulated meat differs significantly from structure of control meat. Closely after stimulation shortening of actomyosin complex of muscle fibers is observed as well as its gradual relaxation afterwards, if morphological traits of meat ageing appear beginning from 6 hours post mortem. Non-stimulated meat during chilling shows cold shortening.

Identified changes in microstructure of electrostimulated meat point out to significant acceleration of autolytical process in it (as compared to control meat) and to the absence of excessive destructive violations.

INTRODUCTION: Technological necessity, economic expediency and technical possibility created base for conducting processes of meat chilling with relatively high speed by means of lowering temperature of the surrounding air, as well by raising circulation velocity of the air.

During intensive chilling of hot meat, having high pH-values, irreversible cold shortening happens to actomyosin complex of muscle fibers, this deteriorating quality of meat raw material. Several research workers established (Zayas, 1981; Fik, 1986; Honikel, 1986; Woltersdorf, Honikel 1982) that cold shortening of muscles can be prevented if pH-value is lowered to 6,0. This can be achieved by short application of electric current with definite characteristics to meat carcasses during 120 min after 30-40 min post mortem. To do this low voltage (3-100V) and high voltage (100-1300V) installations can be used.

Nevertheless, by the present moment opinions differ on the subject, which technological stage is more advisable for use of electrostimulation and which should be optimum electrotechnical parameters of this stimulation. Usually, in the process

of study different physical, chemical and biochemical methods of analysis are used, however, few research was devoted to morphological study.

Taking into consideration, that muscle tissue suffers influence of electrostimulation during a long period of time, which, at the moment of stimulation develops high activisation of all metabolic processes and is accompanied by microstructural changes of muscle, the present study aims at elucidating morphological changes in muscle tissue, taking as an example longissimus dorsi muscle of cattle at different periods after electrostimulation and in chilling conditions.

MATERIALS AND METHODS: Longissimus dorsi of steers, taken at the level of 10-12th rib served as material for morphological study. First group included muscles which were non-effected during primary processing, and that is why called controls. Experimental group was subjected to electrostimulation after approximately 30-40 min post mortem, closely after dehiding. Single semiperiodic electric current was used (Voltage - 220V, frequency - 25 Hz, stimulation time - 120 sec). After electrostimulation rapid chilling at -3°C was performed.

For investigation samples of muscle tissue were taken immediately after stimulation, then after 90 min, and finally after 6 and 26 hours.

For study of microstructure under light microscope, material was fixed by 20% formaldegyde, dehydrated and placed in celloidin. Cuts were dyed with hematoxylin-eosine. Ultrastructural studies were performed on a muscle, fixed by glutaraldehyde and 1% osmium quadroxide, dehydrated and poured into mixture of epoxide resins : epon-araldit. After analysis of semithin cuts and orientation of muscle fibers, ultra-thin cuts were prepared which were dyed with uranilacetate and plumbum citrate.

Besides, in the process of chilling, temperature change in muscle (6 cm deep) was monitored as well as at the surface of meat. Simultaneously meat was assessed organoleptically and its pH was measured.

RESULTS AND DISCUSSION: During investigation it was established, that closely after electrostimulation internal temperature of muscle tissue reached 39-41°C, while in control carcasses it was 1-2°C lower; pH-value in experimental and control carcasses achieved 5,9-6,2 and 6,7-7,0 , accordingly.

Muscle tissue after electrostimulation develops pronounced traits of shortage reaction of actomyosin filamentary complex in response to effect of electric current (fig.1). As far as along muscle fibers shortage knots appear, then crosswise drawings on fibers smoothen or are substituted by longitudinal ones. On the ultrastructural level decrease of filaments length is observed as well as initial evidence of postmortem changes in organellae, expressed in swelling of tubular and vasicular structures. At the same time changes of condition of fibers shortage system and cellular aorganellae are not characteristic

of all muscle fibers at the same moment, on the contrary, they possess heterogenic, mozaic character. In control material, taken from non-stimulated carcasses, tissue structure is similar to hot meat structure at this moment, this muscle being in the stage of postmortem relaxation.

After 1,5 hours post mortem temperature of carcasses, monitored after electrostimulation, reached 37-39°C and that of controls - 36-38°C. pH-value then was 6,0-6,3 and 6,6-6,8, accordingly.

1,5 hours after electrostimulation meat shows the whole complex of rigor mortis development. Longitudinal drawings on muscle fibers are noted along with sarcomeres shortening and J-strip disappearing. One can see total swelling of proteins in Z-strip region and loosening of bonds discontinuity, and, consequently, of structure rigidity in myofibrillar bundles. As a result, the already electrostimulated meat starts to accumulate ruptures in myofibrillar bundles and muscle fibers, accompanied by microsplits in the latter. Along with violations in the structure of fibrillar proteins of shortage mechanism we noted some evidence of the destructive processes development in lamellar cellous organellae, such as mitochondriae, endoplasmic reticulum, channels of T-system. The described processes develop unevenly even at this stage and do not embrace at similar degree the whole mass of muscle. Even at the common picture of brightly expressed shortage of actomyosin complex, muscle fibers can be encountered, having long enough relaxed sarcomeres. To identify them with certainty as belonging to the pool of fibers covered by shortening or as fibers initiating phase of fibrillar proteins shortening, belonging to shortage complex, is not possible.

In muscle tissue which served as control and was not electrostimulated, processes of rigor mortis are at their initial stage and microstructure of muscle tissue is practically similar to experimental meat 40 minutes after stimulation. Degree of shortage in this case may be different in adjacent sites.

Further increase of ageing time for control and stimulated meat under conditions of chilling up to 6 hours induces change of pH-value in experimental samples to 6,1-6,3 and in control ones to 6,1-6,5. Microstructural changes of characteristics of elecrostimulated meat more correspond to the stage of rigor mortis accomplishment. The main part of muscle fibers is not included into state of intensive contraction. Length of its sarcomere is big enough, and even wide J-strip can be easily singled out. Breakage processes of lamellar and structural formations in muscle fibers show deepening character by capturing higher amount of fibers and cellular organellae incorporated therein (Fig.2). Muscle fibers of control meat are in the state of contraction (however, of low degree). The main and essential difference in microstructure of control and electrostimulated meat lies in the fact, that destructive processes in the latter are stronger and develop with a higher speed, however, showing lower degree of sarcomere shortening.

Maximum storage time of studied electrostimulated and control meat was 24 hours. At this stage pH-value in experimental carcasses reached 6,2 - 6,4 and in controls 6,3-6,5. For meat raw material taken from electrostimulated carcasses the total picture of structuro-analytical changes is characteristic of the initial stage of meat ageing. These microstructural peculiarities correspond to structural changes of meat in the process of ageing approximately by the third day of storage, as it was previously described (Skalinky , Belousov, 1978). These changes are expressed first of all by specific complex of disrupture of membranous and fibrillar organellae of muscle fibers and by high amount of crosswise slits in muscle fibers. It is worth to note that disrupture of myofibrillar bundles takes place in the region of Z-strip. This phenomenon, accompanied by weeding out of myofibrills, witnesses about loosening of lateral bonds in the complex of protein shortening (Kudryashov L.S., 1989), this being result of autolytical processes. The non-stimulated control meat also shows destructive processes in muscle fibers. Also, 6 hours post mortem control meat shows higher level of sarcomere shortage and lower level of myofibrillar disrupture as compared to experimental meat. In electrostimulated meat as well as in control samples amount of sarcolemma wholesomeness violation is not high.

Results of organoleptical assessment of meat showed, that after chilling surface of muscle tissue of experimental samples had purple-reddish colour, brighter than that of control samples. Degustation showed that according to tenderness and juiciness samples of pre-electrostimulated carcasses after chilling were scored higher. Besides, higher quality of semi-prepared foods was observed, which were manufactured from electrostimulated meat (Kulikovskaya, 3).

CONCLUSIONS: Thus, the use of electrostimulation 30-40 min after slaughter ensures accelaration od initial stages of ageing approximately by 2-3 times. Effect of electric current which accelerates for 6-8 hours pH-fall of meat, prevents the influence of low temperature on structure of myofibrillar proteins and ensures higher tenderness and overall quality of meat raw material.

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Fig. 1 Ultrastructure of meat immediately after stimulation

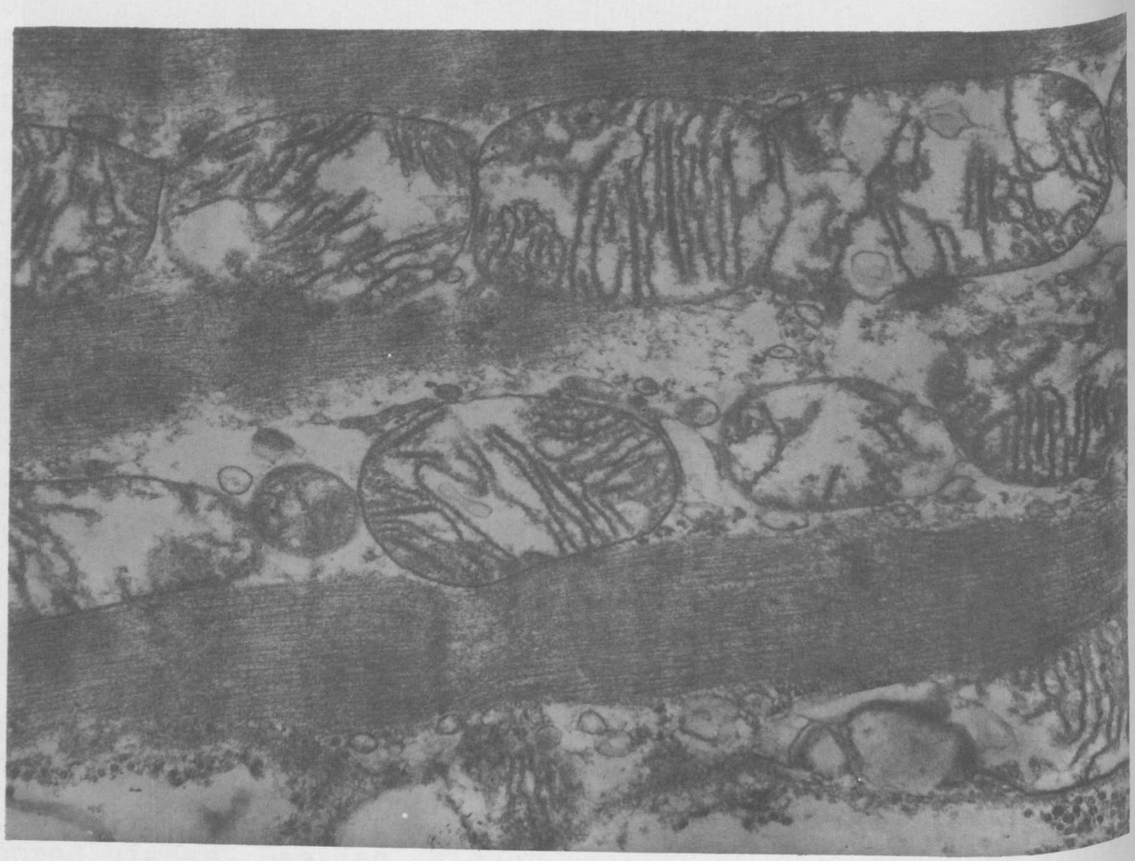

Fig.2 Ultrastructure of meat 6 hours after electrostimulation