6.1 - P7

Ryszard Żywica, Janusz Budny

University of Warmia and Mazury, Chair of Basics of Technique of Energy Management, pl. Cieszyński 1, Olsztyn, Poland

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Background

Electric current flowing through (carcasses, half carcasses) during electrical stimulation, as well as concurrent muscle contraction are the main reasons of the structural changes of muscle tissue. These changes are mostly characterised by the contraction of sarcomeres, physical damage of the myofibrils and their fragmentation on Z-lines (Savell et al. 1978, Sorinmade et al. 1982, Żywica et al. 1998). During muscle contraction, consumption of energy derived from decomposition of adenosinetriphosphate (ATP) occurs. To compensate the loss of ATP, its resynthesis occurs. The energy for the resynthesis is received from accelerated decomposition of muscular glycogen. Oxygen-free conditions produce larger amount of lactic acid. Consequently pH of muscle tissue decreases at about 0.3-0.7 unit (Honikel and Woltersdorf 1982). This rapid fall of pH at high muscle temperature, avoidance of cold shortening and the changes of ultrastructure of muscle tissue are the reasons of improvement of beef meat tenderness applied to electrical stimulation. Additional argument supporting this is the fact that these three mechanisms occur simultaneously during electrical stimulation (Polidori et al. 1996).

Objective

The objective of this study was to estimate the influence of high-voltage electrical stimulation on the structure of beef meat cooled by the accelerated method, stored at 2 °C and derived from half carcasses 72 hours after slaughter.

Material and methods

The half carcasses of heifers, black-white breed, aged about 18 months were the experimental material. Left half carcasses were stimulated with current 330 V, 17 Hz, pulse duty factor 0.9 rectangular-shaped impulses during 120 seconds. The right half carcasses were the control samples. After slaughter and electrical stimulation half carcasses were cooled by the accelerated method. The half carcasses were stored 72 hours at 2 °C. Then the samples of *longissimus dorsi* muscle were taken and fixed in the mixture of 2.5 % glutar aldehyde, 1% paraformaldehyde in 0.2 M in phosphate buffer of 7.4 pH, at 4 °C for 2 hours. Then the material was rinsed in the buffer for 24 h and postfixed in 2% osmium tetroxide in 20 °C for 2 h and dehydrated with ethanol and propylene oxygen. The sections were saturated with resin Epon 812, submerged and polymerised at 35, 45, 60 °C for 96 hours. Then the blocks were cut into ultra thin slices using ultramicrotome LKB and placed on the copper nets. The slices were stained with uranyl acetate and lead citrate. They were looked through and photographed with a Tesla BS 500 TEM at 60 kV.

Results and discussion

Ultrastructure of muscles received from non-stimulated half carcasses is characterised with diversified internal structure of fibres. Considerable part of fibres characterises with well-preserved segmented myofibrils, few of which demonstrate discontinuity. Z line is slightly washed out but quite well-preserved. Residual fibres reveal damaged myofibrils. The sarcoplasm is covered with vacuoles. The looseness of the internal fibre structure is visible. Also, there are small clusters of cell debris (fig. 1A, 1B).



Fig. 1A. Ultrastructure of non-stimulated muscles – longitudinal section. The myofibrils with typical segmented structure and the damaged ones are visible. The spaces left are filled with vacuole sarcoplasm, residual membrane structures and cell debris. Mag. 12 000 x.

Fig. 1B. Ultrastructure of non-stimulated muscles - cross section. Visible loose arrangements of myofibrils in fibres. Mag. 12 000 x.

Ultrastructure of muscles derived from electrically stimulated half carcasses is characterised with the presence of spaces with loosened structure of myofibrils with well-preserved segmented structure. Each myofibril is separated by the area of sarcoplasm with vacuoles and small clusters of cell debris. In great number of myofibrils, discontinuity, loosened and broken Z line is visible. On the cross section of fibres, loose arrangement of myofibrils is visible. The myofibrils are separated by vacuole sarcoplasm which is characterised with single damaged mitochondria and small amount of cell debris (fig. 2A, 2B).



Fig. 2 A. Ultrastructure of stimulated muscles – longitudinal section. The fragment of a fibre with damaged myofibrils and changes in sarcoplasmic structure. Mag. 9 000 x.

Fig. 2 B. Ultrastructure of stimulated muscles – cross section. The fragment of a fibre with visible symptoms of the damaged myofibrils and sarcoplasm. Mag. 12 000 x.

The ultrastructural changes of muscles removed from stimulated half carcasses, the loosening of the myofibril structure, their discontinuity, degradation and break of Z line continuity indicate that electrical stimulation influenced both the kind and speed of post-slaughter changes, which resulted in considerable morphological changes. According to Sorinmade et al. (1982), Soares and Arêas (1995) it is proteolysis that might cause these changes. It occurred because of the rapid fall of pH at high temperature of muscles and decay of lysosome membranes and release of the proteolysis enzymes. The authors: Sorinmade et al. (1982), Soares and Arêas (1995), Taylor et al. (1995), Tyszkiewicz (1995) have stated that these structural changes of muscle tissue have considerable effect on improvement of beef meat tenderness.

Conclusions

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- 1. Damage of myofibrils on Z line, break of their continuity, loose arrangement of myofibrils, which are separated with areas of sarcoplasm with vacuoles, and the presence of cell debris in muscles derived from stimulated half carcasses indicate that the morphological changes in stimulated beef meat are much more advanced than in non-stimulated beef meat.
- 2. The structural changes of muscles (mainly discontinuity of Z line of myofibrils, the presence of sarcoplasm with vacuoles between the myofibrils) derived from stimulated half carcasses indicate that tenderness of stimulated beef meat may be much better than tenderness of non-stimulated beef meat.

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