CHANGES IN THE PROTEOLYTIC ACTIVITY OF LISOSOMAL ENZYMES IN PORK MUSCLES UNDER ELECTRICAL AND MECHANICAL EFFECTS

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SUMMARY

The catheptic activity in pork cured under electrical and mechanical effects was studied biochemically and histochemically. Experiments were made on pork l.dorsi muscles after 2.7 x 10^3 s after slaughter. The right muscles were electrically treated (electrostimulated), injected and massaged in a vacuum mixer. The left muscles were first injected, then electrically treated (electromassaged) and vacuum-massaged. It was established that electrostimulation and electromassaging cause an increase in the catheptic activity. Histochemical studies of hot meat indicated a low activity of the enzymes, it being reflected in the diffusion distribution of the acid phosphatase. Electrostimulation and electromassaging result in the destructive changes of muscle fibres and in the release of big amounts of the enzyme. After vacuum-mechanical treatment a high activity of the acid phosphatase was found. The purposeful application of electrical and mechanical effects to meat activates tissue enzymes and, thus, allows to intensify the process of ageing and curing.

INTRODUCTION

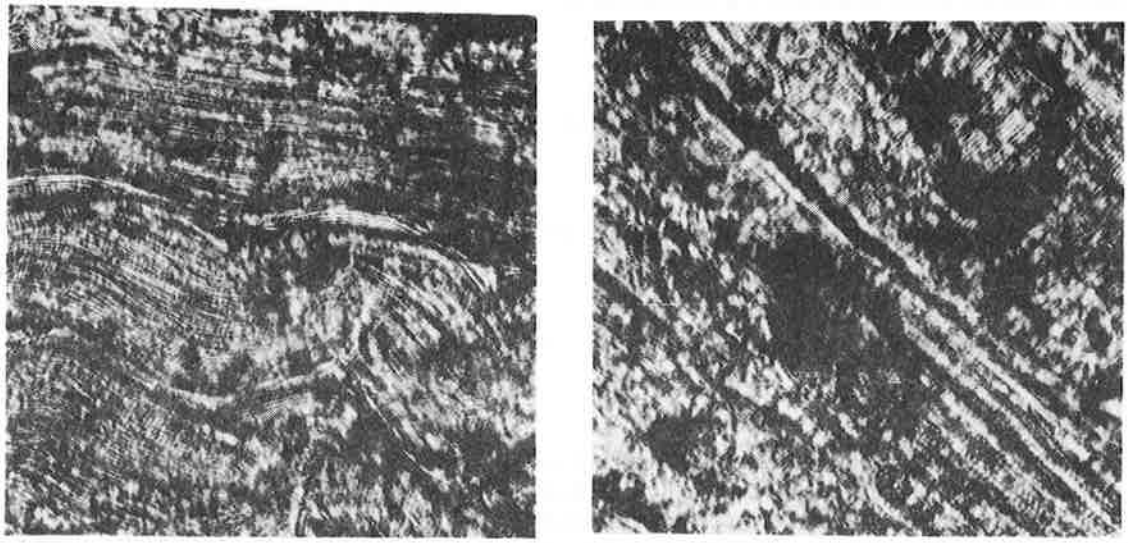
After an animal dies, various enzymic systems are activated in the tissues, which results in meat consistency improvement, in the accumulation of flavour compounds, in a higher digestibility (Bolshakov et al., 1986). Studies of muscle fibres histostructure at different stages of meat autolysis indicated the start of decomposition processes which are connected, according to Dutson et al. (1980) with tissue proteolytic enzymes. In the manufacture of cured meat products raw meat materials are treated in different ways to improve their consistency, to impart a specific flavour, to reduce losses and production process. Undoubtedly, enzymatic processes are of importance for ham and smoked meats technology. Recently, electrostimulation, electromassaging and mechanical massaging of cured meat are finding wider application, they effect the enzymic systems and shortening meat ageing and curing time. In this respect, we performed biochemical and histochemical studies into the catheptic activity of pork muscle tissue.

PROCEDURE

Tests were made on l.dorsi muscles of 9-10 month-old Kemerovo pigs. Hot muscles of the right sides were electrostimulated with the current of commercial frequency (220 Volts, pulse duration 0.4 s, pulse period-to-pulse duration ratio 0.6 s, the total time 3.10^2s) 2.7 x 10^3 a post mortem. Then they were injected with a brine having the density of 1,100 kg/m^3 and consisting of 14% NaCl, 0.075% $NaNO_2$, 1% sugar (at the injection level 10% of the meat weight) and massaged in a vacuum-mixer at 0.35 rps and 283-285 K, at the residual pressure of 29.4 kPa for 7.2 x 10^3 s. The left muscles were injected with the same brine, electromassaged for 3 x 10^2 s and mechanically treated under vacuum for 7.2 x 10^3 s. After every treatment the catheptic activity was biochemically determined according to the earlier described procedure (Kudryashov et al., 1987), and the histochemical pattern of the activity distribution of acid phosphatase, a marker of lisosomal hydrolases, was examined according to Gomori (1950).

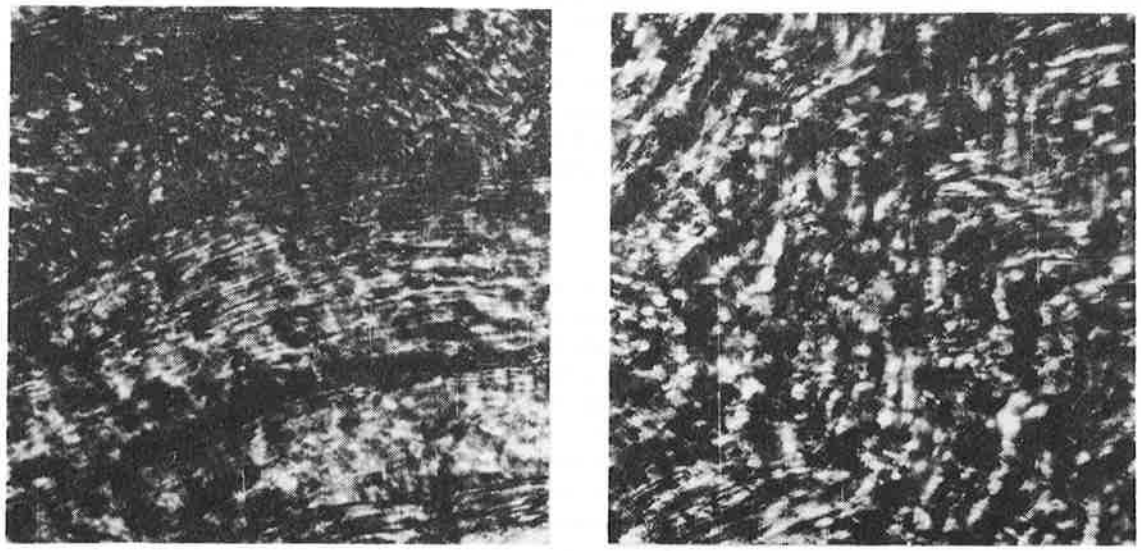
RESULTS

The biochemical results obtained show that the catheptic activity in hot muscles is weak and equal to 0.22-0.28 mcMoles of tyrosine per gram of muscle. Electrostimulation and electromassaging of cured muscles result in a higher activity of proteases (by 2.7 and 2.1 times, respectively). The following vacuum-mechanical treatment of the left and right muscles caused an increase in the proteolytic activity of tissue enzymes. The comparison of biochemical and histochemical results demonstrated the increased activity of tissue proteases during electrical and mechanical treatments. Histostructural data show that just after slaughter the location of muscle fibres in pork is rectilinear, acurragated and folded nature of fibres is evident with some differences in thickness (Fig. 1a). There are few contraction knots, cross striations are well pronounced, sarcolemma is tightly bound with sarcoplasm. The fibres are, mainly, close to each other. The lisosomal enzyme is distributed through the muscle fibre sarcoplasm diffusely and as individual aggregations of dark brown grains. At sarcolemma damaged spots there are found bigger aggregations of enzymes. Electrostimulation results in the destructive changes of muscle fibres as moderate damages, deformation, the occurrence of spaces inbetween fibres (Fig. 1b). Cross striations are not typical of all the fibres. Many fibres are swollen, connective tissue interlayers are loosened. Large amounts of the enzyme are observed between fibres, among protein grains and in the connective tissue interlayers. Acid phosphatase distribution in muscle fibre sarcoplasm is more pronounced in test samples. Injection of electrostimulated meat with brine followed with vacuum massaging causes a considerable extent of destruction of muscle fibres and multiple cross-breakages (Fig. 2a). The fibres are swollen, not clearly defined, cross striations are poorly seen. The location of muscle fibres is rectilinear, wavy or zigzag-like, slits among them are filled with a grained protein mass. The histological pattern resembles a monolith structural link of muscle tissue elements. An appreciable amount of the enzyme present is evenly distributed as small blocks throughout the fibres. In the damaged myofibrils practically no enzyme is found. When studying the influence of electroeffects upon pre-injected hot muscles, it was established that the fibres are moderately swollen and have different configurations (rectilinear, wavy or zigzag-like) (Fig. 2b). There are spaces, slits and microcracks among the fibres. In many places the muscle fibres are deformed and destructed. It was shown histochemically that, in case of cured meat electromassaging, a diffuse distribution of the enzyme without clear local



a b

Fig 1. Acid phosphatase distribution in hot pork muscles (a), after electrostimulation (b) (X 500)



a b

Fig.2. Acid phosphatase distribution in pork muscles after electrostimulation and vacuum-mechanical treatment (a), after electromassaging (b) (X 500)

aggregations is seen in the cracks and among the fibres. Noticeable is the enzyme in the grained protein mass and connective tissue interlayers. The activity of the acid phosphatase is higher than in the hot non-treated meat. The character of the microstructural changes of muscle tissue, mechanically treated under vacuum after massaging, is similar to that of vacuum-massaged electrostimulated muscles (Fig. 3). No cross-striations are seen. The enzyme is distributed throughout the fibre sarcoplasm mainly in a diffuse way, though there are some big local aggregations.

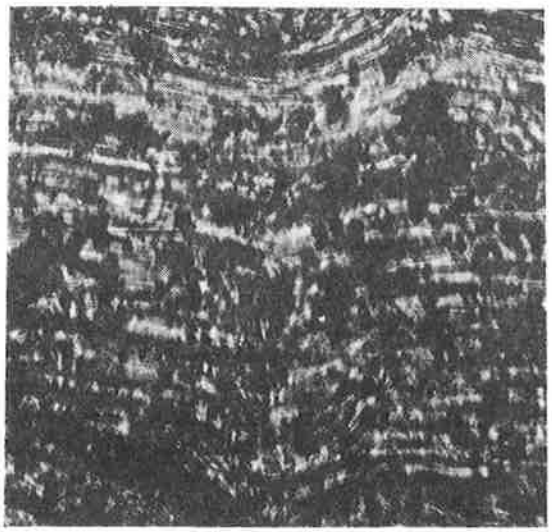


Fig. 3. Acid phosphatase distribution in pork muscles after electromassaging and vacuum-mechanical treatment (X 500)

DISCUSSIONS

The recorded low catheptic activity in hot pork muscle indicate a retarded course of autolytic processes at the initial stage, it being confirmed with the data by Pavlovsky and Simbiryova (1974). An increase in the enzymic proteolytic activity after electrical stimulation and vacuum-mechanical treatment implies destructive processes in the tissues at the lisosomal level. We derived similar data when studying the nature of the catheptic activity in beef (Bolshakov et al., 1986). Dutson et al. (1980) studies the effect of electrostimulation on the activity of lisosomal enzymes in mutton muscles and observed its growth due to the decomposition of the membranes surrounding enzymes. Histological and histochemical analyses demonstrated that electrical and mechanical effects result in enzyme release and localization at the points where muscle tissue elements are damaged.

CONCLUSIONS

On the basis of the performed biochemical and histochemical studies it may be stated that electrical treatment of uncured and cured pork causes a growing free activity of lisosomal enzymes due to their release from the surrounding membranes. The following vacuum massaging contributes to a uniform distribution of the enzymic activity by the structure of fibres, it enabling improved consistency of the raw meat and, therefore, of the finished product. A higher activity of proteases in pork muscle as a result of the application of intensive treatments renders it possible to shorten cured meat ageing duration and to ensure high processing qualities of the raw meats and a high quality of the finished products.

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