6:7

MICROSTRUCTURE OF PORCINE MUSCLES AFTER SCREW PRESS MECHANICAL TREATMENT

P.VELINOV, M.ZHIKOV and E.MARKOV

Meat Technology and Project Institute, Sofia, Bulgaria

SUMMARY

The studies presented treat the possibilities of an original physical method of the technological treatment of meat based on its pressing using the screw of the grinding machine which is rather common in meat processing plants.
Comparative analyses were made using the Semimembranosus muscles of the same animals.Muscles derived from left hams were subjected to the treatment described above, and right ham muscles were treated by brine injection using multi-needle injectors and tumbling in Laska tumblers.
Materials for histological analysis were frozen in isopentane pre-cooled in liquid nitrogen. Histological preparations were stained with haematoxylin-eosin and observed using a Docuval-Carl Zeiss (GDR) light microscope.
Electron microscope studies were conducted using ultra-thin sections contrasted after Reinolds (1963) and observed using a Tesla-BS 613 transmission electron microscope at 80 kV.
Upon the micro- and ultra-structural analyses conducted of hams made of parallel muscle samples, marked destructive changes were observed in muscle fibres, typical of a well processed ham.
On the basis of the microstructural studies conducted, conclusions were made on the efficiency of the investigated method of the mechanical treatment of meat using the screw.

INTRODUCTION

The mechanical treatment of meat used for the production of cooked ham enables the acceleration of technological processes and improvement of the quality of the end product.The methods widely used for mechanical treatment are massaging and tumbling (Heller, 1986). Other methods include electric massaging (Bolshakov, 1982), vibromassaging (Strupin, 1981),etc. All above-mentioned methods necessitatesspecial equipment available, and that is what limits the possibilities of meat-processing plants to speed up their production of cooked ham. There is some evidence about the effect of hydrostatic pressure on the ultrastructure of meat in the specialized literature, but authors face some difficulties as far as the practical industrial application of this physical treatment is concerned (Elgasim et al., 1983).
The present studies aim at investigating the micro- and ultrastructural changes that occur in meat at the process of curing and mechanical treatment using a screw meat grinder.

MATERIALS AND METHODS

Pairs of muscles from the same animals were used in the experiment for an objective and accurate comparison between the results from the mechanical treatment studies here, and the method of tumbling using Laska Inject Star HS3 tumblers, thus ignoring the influence of the raw material. Samples from the left and right side mm. Semimembranosus were prepared from 4 porcine carcasses having pH_{45min} 6.1 ÷ 6.3, and were respectively numerated.
Left side mm. Semimembranosus were treated together with a meat batch for "Round Ham" in the following way: Chilled hindquarter pork, cut into 15 x 20 cm pieces, was double processed in a meat grinder whose cutting knives at the screw outlet had been removed in advance and only a grate with kindey-like openings mounted. After this preliminary treatment the meat was placed into a stirrer and mixed for 3 minutes with 15% salt brine proportional to its weight. The salt brine used had the following composition: 100 l water, 18.5 kg cooking salt, 1.7 kg sugar, 1.3 kg polyphosphate and 0.07 kg sodium nitrite. After curing, the meat was again double processed in the meat grinder in the same way as described above, then was left at +4°C for 18 to 20 hours to ripen. Along with that a well cut stuffing of lean pork was prepared by preliminary minching it on a 2 mm grate and curing it with the above-mentioned salt brine. The stuffing thus obtained was left to ripen at the same conditions like those for the meat. After the ripening period, the cured meat was once again double processed in the grinder, then mixed for 3 minutes in a stirrer together with 10% of the above stuffing proportionally to its weight. The filling thus obtained was packed in polyethylene bags placed in rectangular 6 kg metal boxes. The right side mm.Semimembranosus were at the same time processed together with a meat batch for "Round Ham" on an Laska Inject Star HS3 line in the following way: brine injection using Laska Inject Star TWIN 106 polyinjector and tumbling (30 min tumbling, 30 min interval) in the course of 4 hours under vacuum, then packing in polyethylene bags placed in rectangular 6 kg metal boxes. Both left and right side mm. Semimembranosus were cooked simultaneously in metal barrels and boiled at a water temperature of +74°C for 310 minutes, then cooled in running water for 120 minutes.
The histological studies were performed on muscle cubes with a size of 0.5 x 0.5 x 0.5 cm frozen in isopentane that was pre-cooled in liquid nitrogen. Section of 10 microns thickness, prepared on a Minotom (USA) cryostat and glued onto cover glasses, were stained with hematoxylin-eosin, after fixation in 10% formalin. Observations and microphotographs of the characteristic changes were taken on a Docuval Karl-Zeiss (DDR) microscope by interference light microscopy.
The materials for electron microscopic studies were processed in accordance with traditional methods, and were embedded in durcupan.

Ultrathin sections prepared on a LKB III ultramicrotome were contrasted according to Reynolds (1961). For observation we used TESLA BS-613 electron microscope at 80 kV.

RESULTS AND DISCUSSION

The main role of the screw of the meat grinder is to transport under pressure the meat in the direction of the cutting tools while meat chunks are being pressed, crushed and heavily distorted. This action remains concealed as the meat enters the machine's mouth and is cut to a different extent by the rotating knives. With the knives removed, there is only the screw rotation, with the screw ribs picking up the meat chunks and subjecting them to certain pressure by rubbing against each other as well as against the cylinder walls. The screw ribs crush the meat chunks thus disrupting the muscle fibers. That causes the liberation of the proteolytic enzymes that help the meat mass ripen, and also accelerates the penetration of the salt brine deep into the meat chunks. The grate with the kindey-like openings has the function to counteract the meat flow directed by the screw.

The mechanical treatment we used prior to curing aims at a partial disruption of the muscle fibers thus enabling a better and more uniform penetration of the salt brine. There is a recent tendency towards preliminary physical treatment of the meat raw material prior to its curing. Scheid (1985) achieves that by crushing the meat by ribbed rollers combined with subsequent tumbling.

The microstructural changes in the muscle pairs from both test show well-pronounced disruptive changes in the m scle fibers that are typical of the particular meat product. With control ham (right side mm. Semimembranosus processed in Laska Inject Star HS3 tumblers) the muscle fibers are swollen and closely stuck to each other, with wavy folds at some places and a poorly expressed cross lining. Fissures on the muscle fibers caused by tumbling and rarely covering the whole fiber width can be seen. Myofibrillar proteins extracted by the salt brine and coagulated in the process of cooking can be noticed in the perimisium and among the separate muscle fibers (Fig.Fig.1 and 2). In the test ham (The left side mm. Semimembranosus processed by screw pressing) the destructive changes in the muscularity are similar to those described for the control samples. Typical of this method of mechanical treatment is the crosswise rupture of the muslce fibers all the way along their width (Fig.Fig. 3 and 4). There are also wavy folds in the muscle fibers themselves which are significantly different from the wavy folds in the controls (Fig.3). It is possible that the pressure exerted by the screw has caused these internal foldings. Muscle fibers are partially fragmented to full dissolving of some fragments into a homogenous protein mass (Fig.4).

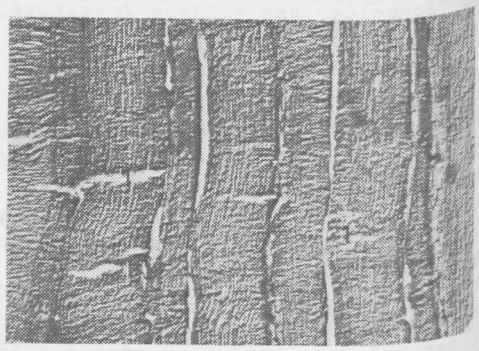

Fig. 1 - Microstructure of control (tumbled) ham. Ruptures in the muscle fibers (1). Magnification x 80.

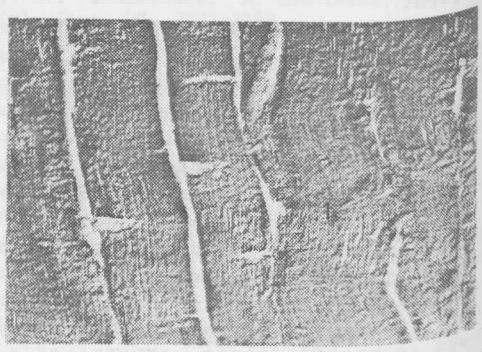

Fig. 2 - Microstructure of control (tumbled) ham. Wavy folding of the muscle fibers (1). Magnification x 80.

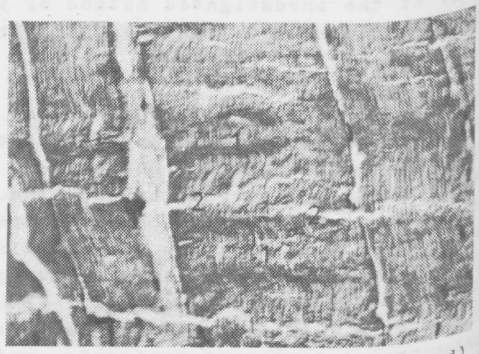

Fig. 3 - Microstructure of test (pressed) ham. Wavy folding of the muscle fibers(1). Ruptures in the muscle fibers (2). Magnification x 202.

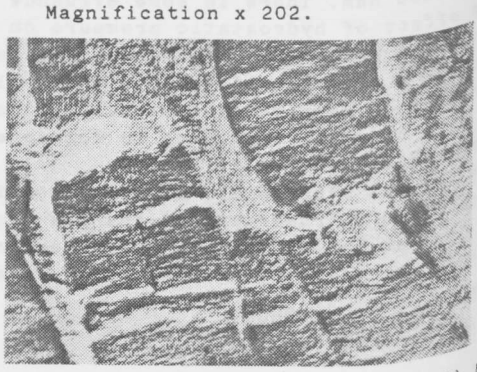

Fig. 4 - Microstructure of test (pressed) ham. Fragmentation of the muscle fibers (1). Magnification x 202.

The ultrastructure of the chilled meat used in the experiment (24 hours after slaughter) is presented on Fig.5. Myofibrils still in the condition of rigor mortis can be seen. H-zones and M-lines are well pronounced. Because of the condition in the myofibrils, I-bands are still in contraction position. Sarcoplasmic spaces are narrow with no glycogen present, and myofibrils with parallel disposition. The ultrastructural changes following curing and screw pressing are illustrated on Fig.6 and 7. Myofibrils are closely sticking together, with disturbed parallel disposition, Z-bands are heavily folded in a zigzag manner and fragmented at some places. The area around them is somewhat lighter as a result of the extraction of the soluble miofibrillar proteins, mainly actin proteins. In some sarcomeres a certain disarrangement of the myofibrils and a partial extraction nd a partial extraction. Heavy to full destruction of the mitochondrial membranes and cristae can be seen in the mitochondria.

The results obtained in the electron microscopic studies resemble to a certain extent the ultrastructural changes occuring under hydrostatic pressure in hot meat from young bulls as described by Elgasin and Kennick (1982). The authors demonstrate swollen mitochondria, swollen sarcoplasmic reticulum, Z-lines disintegration, disappearance of the H-zones, M-lines, triads and T-systems at hydrostatic pressure exertion. MacFarlene and Merton (1978) report similar changes in ovine mm. Semimembranosus, treated postmortally under pressure.

The ultrastructure of both hams after cooking show close attachment of the miofibrils, and disappearance of the borderlines between them (Fig.Fig. 8 and 9). Z-disks and I-bands are completely degraded and extracted, this being more pronounced in the test samples (Fig.9). In some areas the sarcomeres are displaced and completely transformed into homogenous protein mass (Fig. 9).

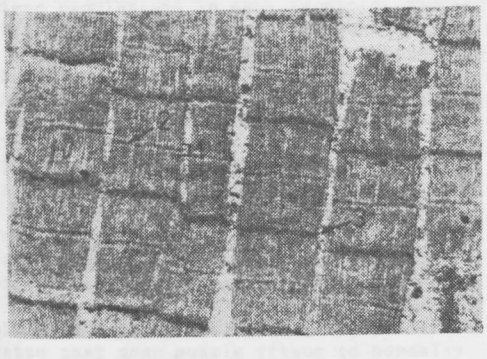

Fig. 5 - Ultrastructure of chilled muscle, a raw material for ham. H-zones (1), M-lines (2), I-sections (3). Magnification x 10 000.

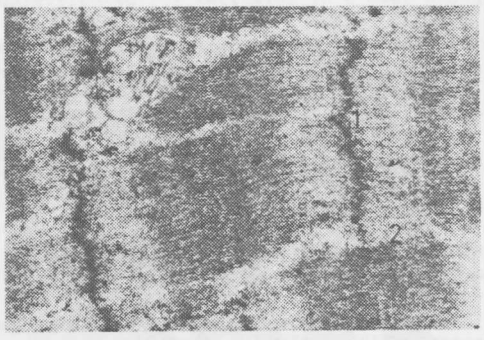

Fig. 6 - Ultrastructure of muscle after curing and pressing. Folding and fragmentation of the Z-lines (1). Extraction of myofibrillar proteins (2). Magnification x 14 000.

Fig. 7 - Ultrastructure of muscle after curing and pressing. Extraction of some parts of the myofibrils (1). Magnification x 14 000.

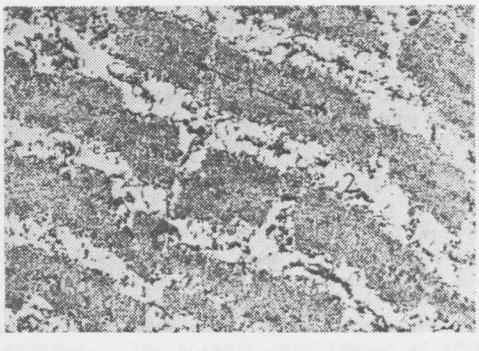

Fig. 8 - Ultrastructure of control (tumbled) ham. Closely stuck myofibrils (1). Extraction of I-sections and Z-lines (2). Magnification x 10 000.

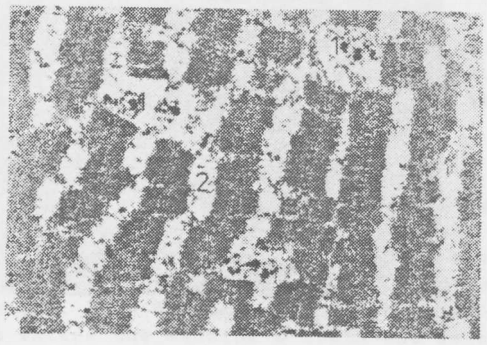

Fig. 9 - Ultrastructure of test (pressed) ham. Sarcomers transformation into homogenous protein mass (1). Extraction of the I-sections and Z-lines (2). Magnification x 4 750.

CONCLUSIONS

The micro- and ultrastructural changes observed here are typical of a well processed ham with both methods of mechanical treatment. This fact indicates that, according to these factors, the mechanical treatment by screw pressing is equivalent to the mechanical treatment by tumbling.

The results from the studies define the screw press mechanical treatment as a reliable method creating the possibility for cooked ham production in the meat-processing plants that lack the specialized equipment.

LITERATURE

1. Bolshakov,A.S., Madagaev, F.A.,1982, Pischevaia techologia, 6, 30-33.

2. Strupin, V.E., 1981, Mesnaia industria, 12, 12 - 13.

3. Elgasime, E.A. and Kennick, W.H., 1982, Food Microstructure, 1, 75 - 82.

4. Elgasime, E.A., Kennick, W.H., Anglemier, A.F., Cochmaraic, M., Elkhalifa, E.A., 1983, Food Microstructure, 2, 91 - 97.

5. Heller, W., 1986, Die Fleischerei, 1, 43 - 44.

6. Mac Farlane, J.J. and Morton, D.J., 1978, Meat Science, 2, 281 - 288.

7. Reynolds, E.S., 1963, J. Cell Biol., 208 - 211.

8. Scheid, D., 1985, Die Fleischwirtschaft, 65, 4, 436 - 441.