

CHANGES IN POULTRY MEAT MICROSTRUCTURE DURING CHILLED STORAGE

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Abstract

Researchers have found that morphology of muscle structure (original or after processing) is closely related to meat tenderness, which is very important attribute for consumer. The aim of the study was to evaluate changes in microstructure of poultry meat during the chilled storage.

In the study, the cross-cut microstructure of parents stock hen and broiler muscles were analyzed during the storage at $+1 \pm 0.5$ °C temperature. The changes were determined for the following muscles: *musculus pectoralis* and *pars praeacetabularis musculus iliotibialis lateralis* in seven hours after slaughter and on the 7th day of storage. Parents stock (PS) hens were slaughtered on 61st week, but broilers at the age of 42 days (on the 6th week).

The decrease in area of muscle fibres of hens and broilers' *musculus pectoralis* was found in both types of meat when comparing the sample on 7th hour and 7th day, but the smaller decrease was observed in broilers meat. Comparing muscle fibre area of broiler and hen *pars praeacetabularis musculus iliotibialis lateralis* [*musculus biceps femoris*] in hen meat it was reduced in higher proportion, but the distance between the fibres was increased reaching similar values for both sample types.

Key words: broiler, parents stock hen, cross-cut microstructure, muscle fibre area.

Introduction

Researchers have found that muscle texture (original or after processing) is closely related to meat tenderness, which is very important attribute for consumer. The most important factors determining meat texture are myofibrillar proteins, muscle cytoskeleton, and intramuscular connective tissue (Wattanachant et al., 2005).

Muscle tissues consist mainly of proteins, which are the most valuable component of meat. It is formed from single fibres (10 - 100 µm in diameter, and up to 12 cm in length), which contain longitudinal protein filaments – myofibrils, which causing the contraction of muscles. Each muscle fibre is covered by thin, flexible connective tissue membrane – sarcolem. The space among fibrils is filled with sarcoplasm, which is formed by semi-liquid proteins. Inclusions of glycogen, lipids and other water insoluble substances are found in sarcoplasm. Myofibrils contain proteins with various light refraction coefficients (Varnam and Sutherland, 1995).

The active part of muscles is the longitudinal muscle fibers, but the passive part – connective

tissues. Each muscle fiber is surrounded by the connective tissue – endomysium. Muscle fibers are bound together by perimysium into bundles called fascicles; the bundles are then grouped together to form muscle, which is enclosed in a sheath of epimysium, which is connected to perimysium. The thickest connective tissues are visible in the muscle cross-cut. Epimysium encloses each muscle separating it from other muscles and providing the independent contractions (Brüveris, 2007).

Bird muscles can generally be divided in two types: white and red muscles. White or pale muscles typically are little loaded (for example, hen's breast). These muscles contain bigger amount of myofibrils and smaller amount of sarcoplasm (Brüveris, 2007).

A muscle consists of approximately 750 g kg⁻¹ of water, 200 g kg⁻¹ of protein, 30 g kg⁻¹ of fat and 20 g kg⁻¹ of non-protein nitrogen. Water is found between muscle fibers, within sarcoplasmic reticulum and in the sarcoplasm itself. Mainly it is found as free water within the space between actin and myosin filaments (Lawrie, 1991).

The aim of the study was to evaluate changes in the microstructure of poultry meat during the chilled storage.

Materials and methods

Broilers and parents stock hens of the cross Ross 308 were used for the study. The age of broilers before slaughter was 42 days (on the 6th week). Among slaughtered birds, about 60% were hens and 40% - cocks. An average carcass weight of a bird was 1.67 kg. The slaughter and primary treatment was performed at a meat processing plant (line Stork PMT). Broilers were stunned, then killed with a knife, bled for 2.25 minutes, scalded in a steam bath at 56 ± 0.2 °C for 2.35 minutes, defeathered, eviscerated and chilled for 100 minutes at $+1 \pm 0.5$ °C.

The age of PS hens of the cross Ross 308 used for study were 61 week, an average hen's carcass weight was 2.9 kg. The slaughter and primary treatment was performed at a meat processing plant (line Stork PMT). PS hens were stunned, then killed with a knife, bled for 4.26 minutes, scalded in a steam bath at 60.2 ± 0.2 °C for 4.44 minutes, defeathered, eviscerated and chilled for 100 minutes at $+1 \pm 0.5$ °C.

Two carcasses of each sample group were selected randomly and divided obtaining fillet *musculus pectoralis* and legs *pars praeacetabularis musculus iliotibialis lateralis* [*musculus biceps femoris*]. The divided poultry meat was stored in a cold room at $+1 \pm 0.5$ °C for 7 hours after slaughtering and seven days before sample preparation.

In the process of muscle anatomic section preparation, the following main operations were completed:

- cutting of the sample piece (1x1x0.5 cm) from raw poultry meat of broiler and hen *musculus pectoralis* un *pars praeacetabularis musculus iliotibialis lateralis* [*musculus biceps femoris*] and placing of those in special moulds;
- fixing of the material in 10 % formaline solution at 20 ± 1 °C for 24 h;
- dehydrating of the material and defatting in 70° ethanol for 1 h in 80° - 90° ethanol for 1 h in 95° - 96° ethanol for 2h and in absolute ethanol for 24 h at 37 ± 1 °C;

- inclusion in paraffin:
 - at 37 ± 1 °C: in chloroform for 30 min.; another time in clean chloroform for 30 min.; for 30 min. in a mixture of chloroform and paraffin at ratio 1:1;
 - at 60 ± 1 °C and keeping in paraffin for 1 hour, one more time in clean paraffin for 2 h;
- placement of samples in single - use moulds and filling with paraffin;
- chilling and hardening of the samples.

For cutting of the prepared samples in 5 µm layers, a device Microm HM315 was used. Preparations were placed on a glass slide and air dried. For paraffin dissolving, the slide glass with the sample was subsequently placed in chloroform and ethanol, with holding time - 5 minutes in each (Kondratovics, 1976).

The observation of muscle fiber transversal section was completed under the triocular microscope Axioskop 40 ('Zeiss'). The pictures of the microstructure were taken with digital camera using the 10 x 40 magnification of the microscope. Triplicate analyses were completed per each sample type. Fiber area and distance between fibres was measured using software Axiovision Le Rel 4.5. Ten measurements were done for muscle fiber area, and 20 measurements - for distances. The average values are presented in figures and in the paper.

Results and discussion

The muscle structure varies depending on muscle types, species, and breed of animal, all of which contribute to differences in the texture of the muscles. Peremysium thickness varied depending on the muscle types of chicken, and had a high correlation with the shear value (Wattanachant et al., 2005; Liu et al., 1996).

The photos of transversal muscle section of each sample were obtained in a microscope (Figure 1).

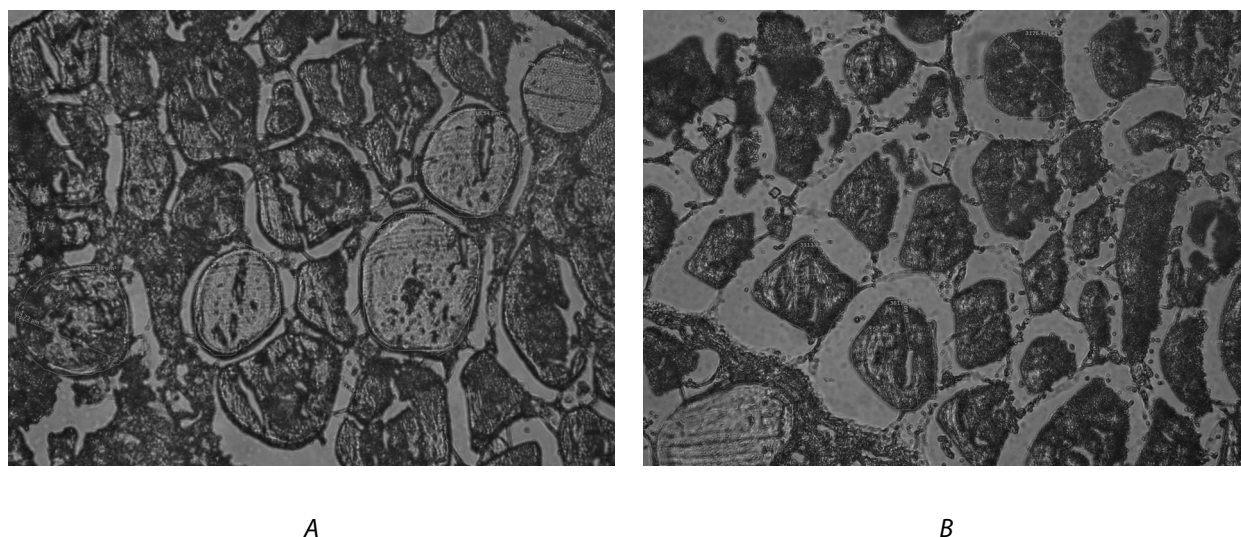


Figure 1. Transversal section microstructure of broiler *musculus pectoralis* in 7 hours after slaughter (A) and on 7th day of storage (B).

The results obtained after measuring the areas of muscle fibers of broiler and hen *musculus pectoralis* after 7 hours and 7 days of storage are presented in Figure 2.

Various researchers have stated that the changes are observed during the raw meat storage, as well as after meat processing. Endomysial shrinkage and subsequent changes in muscle cell diameter with heating have been noted (McCormick, 1999). Comparing broiler muscle *m. pectoralis* fiber area in seven hours and seven days, the fiber shrinkage by 32.43% was observed. The change in area size of hen muscle *m. pectoralis* fiber in seven hours and seven days of storage was 56.59%.

The researchers shows that the hen *m. pectoralis* muscle fiber area, compared to broiler muscle area seven hours after slaughter, was by 33.61% bigger. Differences in muscle fiber diameter may have been due to the differences in age, rate of rigor onset, and degree of sarcomere shortening (Smith and

Fletcher, 1988). But the area size of muscle fiber of this muscle group after seven day storage was similar for both samples. During rigor, the cross-sectional area of the muscle declines due to lateral shrinkage causing the myofibril space of decrease. This results in loss of fluid from the myofibrillar space (Offer and Trinick, 1983).

The changes in broiler and hen muscle fiber *pars praeacetabularis musculus iliotibialis lateralis [musculus biceps femoris]* area observed during the chilled storage after seven hours and seven days are presented in Figure 2. Comparing the muscle *m. biceps femoris* fiber area after seven days it can be concluded that the area is reduced by 9.21 % and 36.86 % for broiler and hen muscles respectively.

Comparing muscle fiber area of broiler *m. biceps femoris* in 7 hours after slaughter and on the 7th day of storage it was found that the area shrank by 9.21%, but the area of hens' muscle fibers reduced by 36.86%.

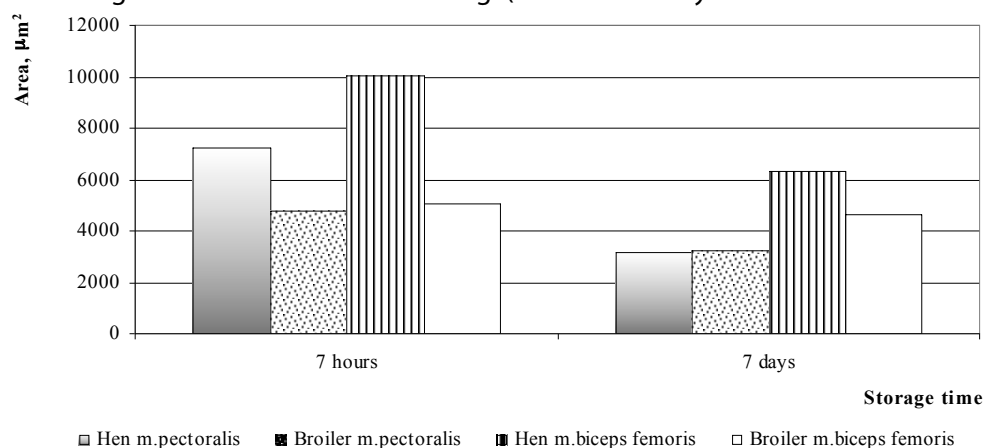


Figure 2. The transversal section area of broiler and hen *musculus pectoralis* and *musculus biceps femoris* measured in a picture of microscopic structure.

The changes in a distance between broiler and hen muscle *m. pectoralis* fiber during the storage are presented in Figure 3.

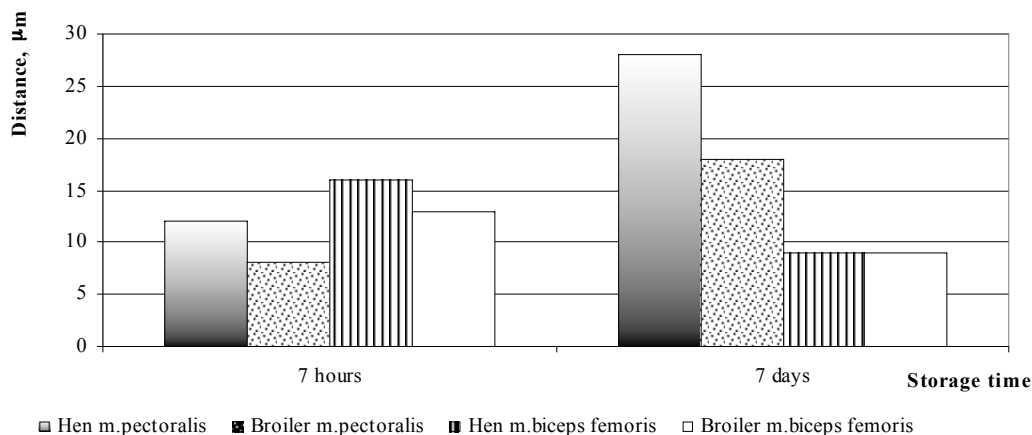


Figure 3. The distance between muscle fibers in transversal section of broiler and hen musculus pectoralis and musculus biceps femoris measured in a picture of microscopic structure.

Comparing the distance between broiler muscle *m. pectoralis* fibres taken in µm in 7 hours after slaughter and on the 7th day of storage, the increase of 2.25 times can be observed; whereas the distance in hens' muscle fibers increased 2.33 times.

The changes in a distance between broiler and hen muscle *m. biceps femoris* fiber during the storage are also presented in Figure 3. The distance between fibers of hen *m. biceps femoris* seven hours after slaughter was 1.28 times bigger, but on the seventh day of storage the average distances were very similar.

Comparing the distance between broiler muscle *pars praeacetabularis musculus iliotibialis lateralis* fibers in the samples taken seven hours or seven days after slaughter, a difference was observed: the distance was 1.44 times smaller; whereas the distance between hen muscle *pars praeacetabularis musculus iliotibialis lateralis* fibers decreased 1.78 times from 7th hour to 7th day of storage during the storage.

Stiffening (*rigor mortis*) follows slaughtering,

therefore muscles become more dense and stiff. If the animal is fatigued then stiffening takes place very fast, sometimes even during slaughter. In 24 hours meat becomes tender, juicy; it obtains flavour and little sour aroma. After pressing on the muscle, juice is exuded. This process is called "meat maturation". Muscle enzymes and proteins participate in the mentioned process (Лебедева, et al., 1985).

Conclusions

The decrease in area of muscle fibres of PS hen and broiler *musculus pectoralis* was found in both types of meat when comparing the sample on 7th hour and 7th day of storage: 32.43% for broilers and 56.59% for hens respectively. The distance between bird muscle fibers was increased.

Comparing muscle fibre area of broiler and hen *musculus biceps femori* in hen meat it was reduced in higher proportion: 9.21% for broilers and 36.86 % for hens respectively. The distance between the fibres was increased reaching similar values for both sample types.

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