

The effect of chilling and freezing on histological structure in slaughter poultry

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Abstract

This study focused on the evaluation of morphometric histological changes in the muscles of chicken carcasses before and after two types of cold treatment. Air-spray chilling and the IQF (individual quick freezing) method were used. The diameter of the muscle fibres in breast and thigh muscles was measured. A statistically highly significant increase ($P < 0.001$) in muscle fibre diameter was found between the control group and air-spray chilling group and a statistically significant decrease was found between the control group and the thigh muscle IQF freezing group. Air-spray chilling caused a statistically significant increase ($P < 0.05$) in muscle fibre diameter in breast muscles, though a statistically highly significant decrease ($P < 0.001$) in muscle fibre diameter was found after IQF freezing. Muscle fibre diameters were higher in the control group, air-spray chilling group and breast muscle IQF freezing group. According to the results obtained, we can conclude that histology is a reliable method for the study of muscle fibre damage and, therefore, the loss of biological value in chicken meat after different types of low-temperature preservation.

Chicken meat, food hygiene, histology, quality

Introduction

Chilling is considered a critical step in the processing of poultry meat. Lowering the temperature slows down or even halts the growth of bacteria, thereby preventing product quality deterioration and extending product shelf life. Air-spray chilling accomplished by circulating air for 1 to 3 hours is one of the most frequently used methods in the process of poultry meat preservation. To accelerate chilling and prevent moisture loss during air chilling, meat is exposed to extremely cold air at a temperature of $-8\text{ }^{\circ}\text{C}$ to $-6\text{ }^{\circ}\text{C}$ at the inlet to the cooling facility and $4\text{ }^{\circ}\text{C}$ to $1\text{ }^{\circ}\text{C}$ and a relative humidity of 85 – 90% at the facility outlet (Sams 2010). Poultry meat is then sprayed with ice-cold water mist. The advantage of this method is the protection of the meat against water loss through drying. After slaughter, poultry carcasses are chilled in order to lower and maintain meat temperature below the level that ensures high-quality and safe products (James et al. 2006). According to European Commission Regulation No. 853/2004, slaughtered animals must be cleaned and chilled to no more than $4\text{ }^{\circ}\text{C}$ after inspection and evisceration.

Freezing is a traditional method of food preservation. In recent years, the method of individually quick frozen (IQF) poultry meat has been used to an increasing extent. The ice crystals created are much smaller and therefore cause less damage to cells and the structure of the food itself. The freezing time is much shorter which shortens the time for the diffusion of salts and separation of water in the form of ice crystals. Meat cuts are flash-frozen to below the temperature at which bacteria, fungi and yeasts are capable of growing which prevents the decomposition of frozen foodstuffs (Pruthi 1999). The temperature after slaughter and shelf life are factors that have a significant impact on the muscle tissue structure (Zelechowska et al. 2012).

The aim of this work was to evaluate the effect of air-spray chilling and individual quick freezing on the histological structure of the breast and thigh muscle tissues in poultry using morphometric methods.

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Materials and Methods

The collected histological samples of breast and thigh muscles were divided into three groups. Control group samples (n = 12) were taken from the breast (n = 6) and the thigh (n = 6) muscles immediately after slaughter; samples for the air-spray chilling group (n = 12) were collected from the breast (n = 6) and the thigh (n = 6) muscles, and IQF group samples (n = 12) were taken from the breast (n = 6) and the thigh (n = 6) muscles frozen using a Jet Freezer CT 2392 (Carnitech, Denmark). Histological samples of breast and thigh muscles were processed into paraffin blocks for light microscopy, stained with haematoxylin and eosin, and images of them taken with a Jenamed light microscope (Jenamed 2, Carl Zeiss AxioCam Erc 5s, 600x). Two cross-sectional diameters of muscle fibres were measured using Photoshop CS 5. The results were subjected to statistical analysis (GraphPad Prism 2007).

Results and Discussion

In comparison with the control group (Plate IV, Fig. 1), air-spray chilling of breast muscle tissue caused a statistically significant increase ($P < 0.05$) in muscle fibre diameter, while a statistically highly significant reduction ($P < 0.001$) was seen in the diameter of muscular fibres treated with the IQF technique (Plate IV, Fig. 2). White muscle fibres are anaerobic-type fibres. Their diameter is greater than the diameter of red muscle fibres.

A highly statistically significant increase ($P < 0.001$) in the muscle fibre diameter between the control group and the air-spray chilled group (Plate IV, Fig. 3) and a statistically significant reduction ($P < 0.05$) in the muscle fibre diameter after IQF were found in the thigh muscle tissue. Red muscle fibres are aerobic-type fibres. Their diameter is smaller than the diameter of white muscle fibres.

Breast muscles (white muscle tissue) consist of type II white glycolytic fibres. Thigh muscles (red muscle tissue) contain about 30% oxidative glycolytic fibres. The two types of muscle fibres differ from each other in a number of physical characteristics (Henckel et al. 2006). The mean fibre diameter values of breast muscle tissue were greater in the control group, the air-spray chilling group and the IQF group than in red muscle tissue (Table 1).

Table 1. Muscle fibre diameters (mean \pm SD) measured before and after air-spray chilling and IQF

Group	Muscle fibre diameter [μm]	
	Breast muscle tissue	Thigh muscle tissue
Control	45.970 \pm 4.997	40.513 \pm 4.250
Air-spray chilling	47.812 \pm 3.789	44.125 \pm 3.395
Individual quick freezing	34.643 \pm 3.106	30.197 \pm 3.767

Myofibrillar proteins are responsible for water binding capacity (Steinhauser 1995). White muscle tissue has a higher myofibrillar protein content and its water binding capacity is therefore higher, while red muscle tissue has less myofibrillar protein and its water binding capacity is correspondingly lower. During the course of chilling, greater binding of water causes an increase in muscle fibre diameter. The water binding capacity of red muscle tissue is further reduced by its higher fat content (Choi and Kim 2009).

Conclusions

Chilling and freezing are among the most common methods of food preservation, though these methods can also affect the histological structure of meat. Differences in the size of muscle fibres were ascertained histologically. This fact indicates the different water binding capacity of the white muscle tissue of air-spray chilled slaughter poultry than that of red muscle tissue. Water binding capacity is caused by a higher content of

myofibrillar protein in white muscle tissue. In the previous study, was described increased water binding capacity of breast muscle tissue in comparison with red muscle tissue (Botka-Petrak et al. 2005). Water binding in the process of air-spray chilling is, however, affected by several factors, such as the pH, the number of groups available for water binding and the temperature. IQF reduced the muscle fibre diameter without damaging the fibres, leading to the preservation of the biological value of the poultry meat. Based on the results obtained, we can conclude that histology is an appropriate method for study of the biological value of poultry meat after its low-temperature preservation.

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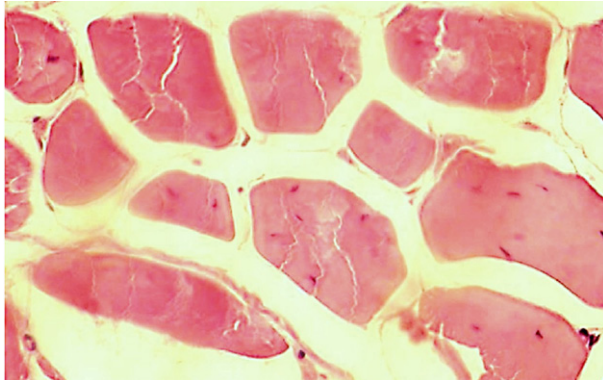


Fig. 1. Control group, muscle fibres of breast muscle (*m. pectoralis superficialis*); haematoxylin – eosin staining; 600x magnification

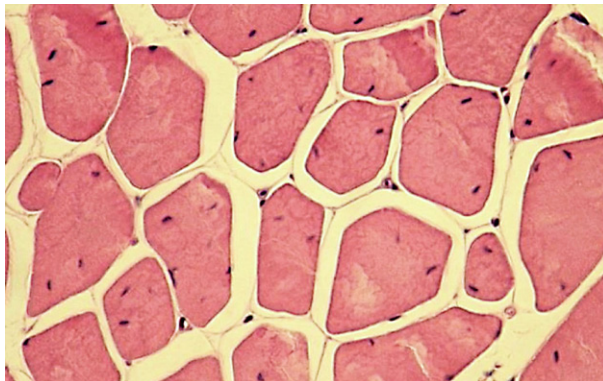


Fig. 2. Individual Quick Freezing group, muscle fibres of breast muscle (*m. pectoralis superficialis*); haematoxylin – eosin; 300x magnification

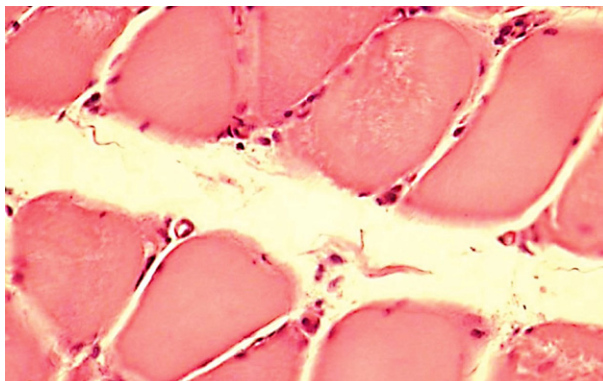


Fig. 3. Air-spray chilling group, muscle fibres of thigh muscle (*m. iliobtibialis*); haematoxylin – eosin staining; 600x magnification