PE4.94 Microstructure and Water Holding Capacity of PSE and DFD Chicken Broilers Breast Muscles in Autumn-Winter Period 334.00

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Abstract—The aim of the study was to present influence of autumn-winter season, distance of bird's transportation (65, 80, 120, 140 and 220 km) and time of selection (3 and 24 h p.m.) on chicken broiler breast muscle water holding capacity (WHC) and microstructure. The muscles were selected for PSE (pale, soft, exudative), "normal" (N) and DFD (dark, firm and dry) on the basis of their color lightness (L*), pH and subjective color evaluation. WHC and muscle microstructure were used to determine intensity of meat defects. The incidence of PSE and DFD in chicken breast muscles was higher in autumn than in winter and PSE and N muscles had lower and DFD muscles higher WHC when compared with corresponding values for winter. The highest incidence of breast chicken muscle defects was observed after shorter (65 and 85 km) and longer (220 km) distances of bird's transportation. Microstructure of PSE and DFD muscles was characterized by higher muscle fiber diameter in comparison with N muscles. In PSE muscles interfiber spaces were higher while in DFD muscles were lower than that for N muscles. Selection of muscles after 24 h p. m. was more conclusive than that after 3 h p.m.

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Index Terms—PSE and DFD, chicken breast muscle, microstructure, WHC.

I. INTRODUCTION

The occurrence of PSE and DFD meat is caused by many ante- and postmortem factors, and the reduced quality in PSE meat has a significant, negative economical impact. Genetic, biochemical, metabolic and environmental factors contribute to the problem [1, 6]. The pale breast meat, similar to the defect observed in pig muscles, defined as being PSE is also characterized as having an abnormally low p.m. muscle pH. In contrast, the darker breast meat, compared to condition DFD observed for bovine species is characterized as having an abnormally high p.m. meat pH. Such meat has limited technological value. Therefore, it is important to minimize the occurrence of this phenomenon by better knowledge of conditions affecting their incidence. The influence of such factors as genotype, season of the year, transportation, holding conditions before slaughter on color parameters, pH, WHC and texture of breast chicken muscle is well documented in literature [2, 3, 4]. However there is lack information about how ante-mortem conditions influence the microstructure of meat. Therefore, the aim of the present study was to estimate the effect of autumn-winter period, bird's transportation and time of measurement p.m. on microstructure and WHC of chicken broiler breast muscles. The study tested the hypothesis that ante-mortem factors influence the microstructure of breast broiler muscles p.m.

II. MATERIALS AND METHODS

A. Experimental design

Birds from Cobb 500 lineage from different farms located 65, 80, 120, 140 and 220 km from the processing plant were slaughtered in industrial conditions during autumn-winter months. In four separate experiments color parameters (L*,a*,b*) and pH of 50 randomly chosen muscles were measured after 3 h p.m. and in four another experiments measurements were done on muscles after 24 h p.m. Color parameters (L*,a*,b*) were measured three times along the longitudinal axis of each muscle by spectrometer Minolta CR-400. The pH was determined in duplicate using pH-meter Testo 230 by inserting electrode into the each examined muscle. The color of each muscle was estimated subjectively by 4-5 plant workers. On the basis of lightness (L*), pH and color subjective assessment from each 50 muscles were chosen 4 within three groups: lighter than normal

(L*>53; pH<5.7), normal (48<L*<53; 5.7<pH<6.0), and darker than normal (L*<48; pH>6.0) for subsequent analysis. Then vacuum packed muscles were transported in cooler to University laboratory.

B. Water holding capacity (WHC)

Chicken muscles were trimmed of visible fat and connective tissue and then were ground in a laboratory grinder through a 3 mm orifice plate. WHC was measured according to Grau-Hamm method with Szmanko modification [8] and was expressed as percentage of water which remained in sample after 5 min. pressure (19.62 N) related to initial water before pressure.

C. Microstructure

Histometrical measurements were performed under the light microscope. For staining of tissue sections Delafield's hematoxylin and eosin were used. Muscle fiber diameter and interfiber spaces were measured.

D. Statistical analysis

All the results were analyzed statistically using Statistica 8.0 program with one-way analysis of variance at the significance level of P<0.05.

III. RESULTS AND DISCUSSION

The incidence of PSE and DFD in chicken breast muscles was higher in autumn than in winter period (Table 1). Water holding capacity of PSE and N muscles was significantly lower and DFD muscles significantly higher in autumn than corresponding WHC muscle values for winter. In both periods normal muscles WHC was in between that for PSE and DFD muscles, respectively. The influence of bird's transportation, as a function of the distance from the farm to the plant, on meat quality is presented in Table 1. The WHC of N and PSE muscles was not affected by short transportation distance (65 km) contrary to DFD muscles WHC which was significantly higher than average for the remain samples from DFD muscle group. In that part of experiment birds were under two stressful factors: catching and cratining and short distance transportation. The 80 km transportation resulted in slight increase of N muscles WHC and decrease of DFD muscle WHC (bird's adaptation) but PSE muscles WHC significantly decreased. For 120 km transportation was observed further quality improvement of normal muscles and increase of PSE muscles WHC. The longer transportation distances (140 and 220 km), and higher birds tiredness, had detrimental effect on N and PSE muscles WHC and in lesser extent on DFD muscles WHC. For each transportation distance the significant differences were found between WHC of N, PSE and DFD muscles. The WHC of N, PSE and DFD breast broiler chicken muscles selected after 3 and 24 h p.m. are presented in Table 1. WHC of N meat after 24 h p.m. was lower than that after 3 h p.m. in result deterioration of native functional properties of proteins. Lower PSE muscles WHC and higher DFD muscles WHC after 24 than after 3 h p.m. reflect the higher intensity of changes in that type of muscles. The changes in N, PSE and DFD muscle quality determined by WHC correlated with changes in muscle microstructure (Table 2). The relation between microstructure of muscle and WHC was found by other authors [2, 5, 7]. Deterioration of N and PSE muscles quality (decrease of WHC, winter-autumn) corresponded with increased interfiber spaces and in case of DFD muscles (autumn-winter) with decreased interfiber spaces (Figure 1-6). The structural changes were in accordance with muscles fiber diameter. The muscle fiber diameter of N muscles was significantly lower (35 μm) than defective muscles, i.e. PSE (38 μm) and DFD (36.8 μm). Irrespective of described structural changes the chicken N, PSE and DFD muscles had well preserved architecture with distinguished endomysium.

IV. CONCLUSION

The chicken "normal' (N) broiler breast muscles in autumn had lower WHC than in winter. The autumn measured PSE and DFD muscles were more defective in respect to WHC than that measured in winter. The distance of bird's transportation had different influence on WHC of N, PSE and DFD muscles. WHC of N muscles was improving with increase of bird's transportation distance up to 120 km. The incidence of changes in defective meat of PSE and DFD was higher in the case of short time bird's transportation (65 and 85 km) and its extension (220 km). WHC changes between autumn and winter period in N, PSE and DFD muscles were related with interfiber space differences (increase in N and PSE muscles and decrease in DFD muscles). The fiber diameter was higher in defective muscles in comparison with "normal" muscles. Selection of muscles into N, PSE and DFD is more preferable after 24 than after 3 h p.m.

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Table 1. Influence of the autumn-winter period (n=150), birds transportation distance (n=50), selection time 3 and 24 h p.m. (n=100) on water holding capacity (WHC, %) of breast chicken broiler "normal" (N), PSE and DFD muscles

	Type of muscle		
	N	PSE	DFD
Period			
Autumn	56.93^{bA}±3.34	54.45^{aA}±2.62	61.44^{cB}±2.56
Winter	57.76^{bB}±1.92	55.21^{aB}±2.25	59.66^{cA}±2.23
Distance			
65 km	57.02^{bAB}±2.37	56.25^{aB}±1.30	63.02^{cD}±1.76
80 km	57.55^{bB}±2.13	53.17^{aA}±1.45	58.16^{bA}±2.68
120 km	59.39^{bC}±1.02	57.16^{aC}±1.77	60.13^{cB}±1.04
140 km	57.63^{bB}±2.69	53.62^{aA}±1.69	61.39^{cC}±2.32
220 km	56.11^{bA}±4.49	53.47^{aA}±3.27	59.89^{cB}±2.57
Time p.m.			
3 h	57.01^{bA}±1.83	55.06^{aB}±1.80	60.49^{cA}±1.97
24 h	56.60^{bA}±3.72	54.26^{aA}±2.81	62.00^{cB}±2.51

$^{a\text{-}c}$ Means in the same row and $^{A\text{-}B}$ Means in the same column having the same superscript are not significantly different (*P*<0.05), separately for period, distance and time p.m.

Table 2. Influence of autumn-winter period on interfiber spaces (µm) of breast chicken broiler "normal" (N), PSE and DFD muscles (n=100)

	Type of muscle		
	N	PSE	DFD
Interfiber spaces			
Autumn	5.0^{bB}±0.09	9.2^{cB}±0.12	4.4^{aB}±0.07
Winter	4.6^{bA}±0.08	7.6^{cA}±0.07	4.2^{aA}±0.07

$^{a\text{-}c}$ Means in the same row and $^{A\text{-}B}$ Means in the same column having the same superscript are not significantly different (*P*<0.05).

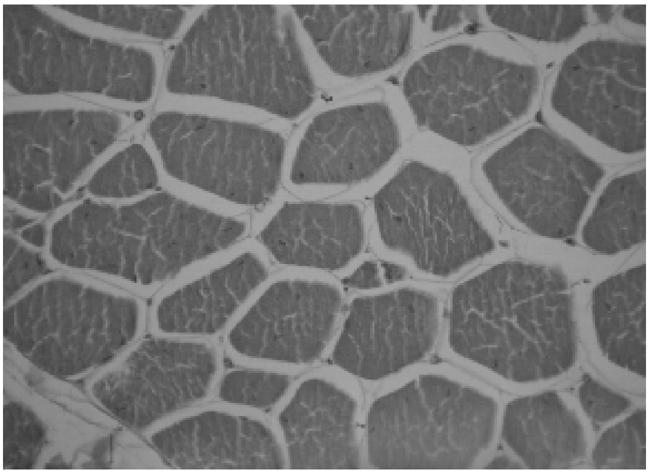

Fig. 1. Structure of breast chicken broiler „normal” muscle for autumn period, magnification 300x

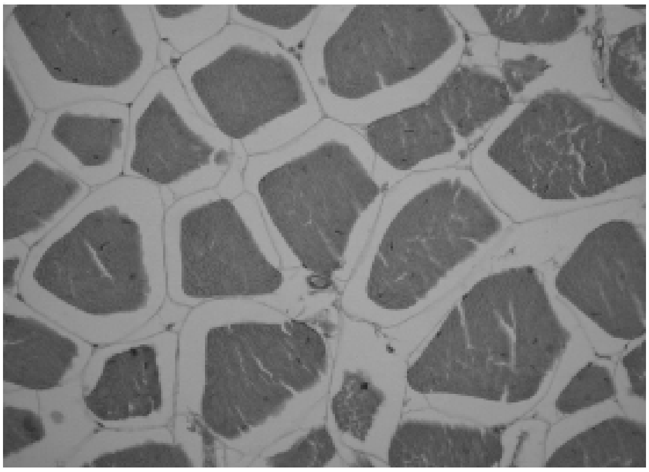

Fig. 2. Structure of breast chicken broiler PSE muscle for autumn period, magnification 300x

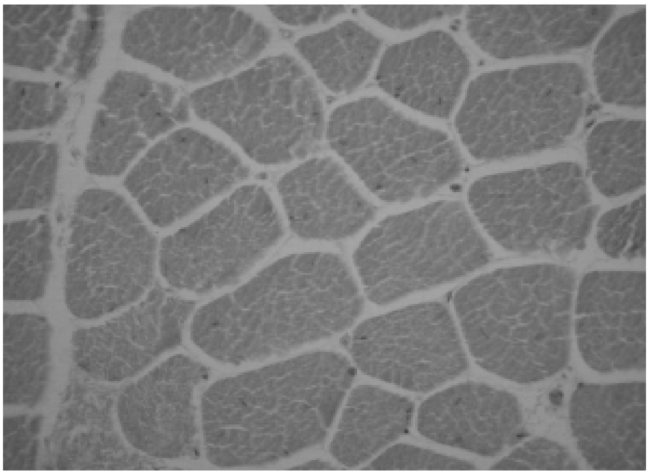

Fig. 3. Structure of breast chicken broiler DFD muscle for autumn period, magnification 300x

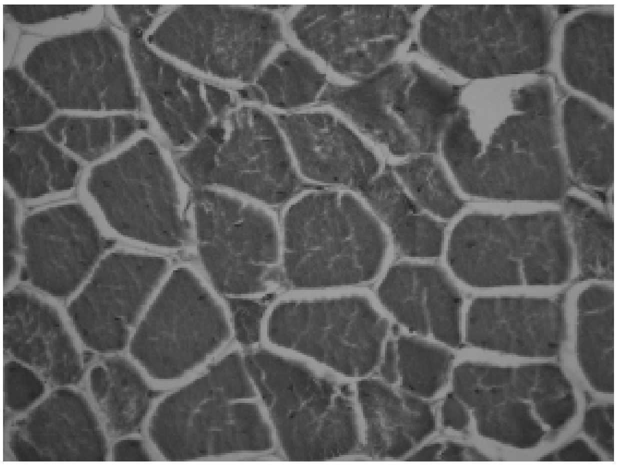

Fig. 4. Structure of breast chicken broiler “normal” muscle for winter period, magnification 300x

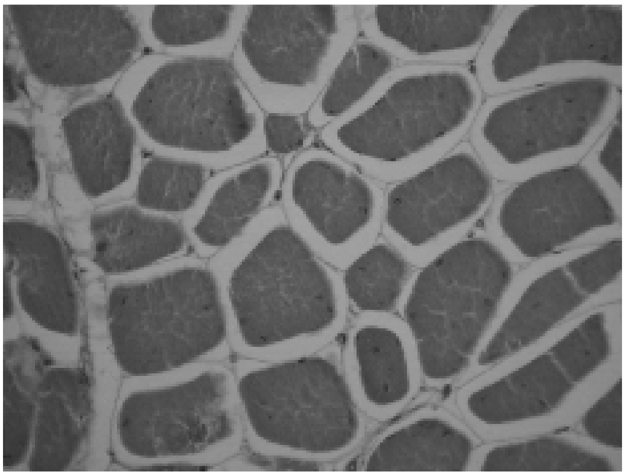

Fig.5. Structure of breast chicken broiler PSE muscle for winter period, magnification 300x

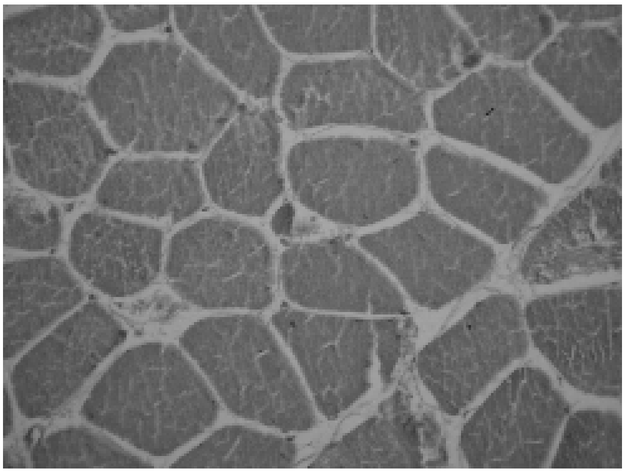

Fig. 6. Structure of breast chicken broiler DFD muscle for winter period, magnification 300x