

DEEP PECTORAL MYOPATHY IN BROILER CHICKENS

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Received for publication April 23, 2009

Abstract

The aim of the study was to conduct an analysis of the main symptoms of deep pectoral myopathy (DPM) in broiler chickens, which is manifested by changes in colour and texture of the affected muscle. The research was conducted on Ross508 chicken broilers, at an age of 35-42 d. The lesions were assessed through macroscopic inspection, using colour parameters as well as texture analysis. Furthermore, the factors affecting the occurrence of DPM were registered. Significant differences in the colour and texture of the breast fillets at various stages of the myopathy were demonstrated. The colour of the muscle turned from pink to red or green, depending on the progression of the disease; the tissue affected with the DPM syndrome was three times as tough as normal, and much more fibrous. Degenerative changes in the *musculus pectoralis major* were observed in 64% of DPM chickens. It was concluded that the weight and age of the bird influences the frequency of the occurrence of DPM (a positive linear correlation).

Key words: broiler chicken, deep pectoral myopathy, muscles, pathology, colour, texture.

Deep pectoral myopathy (DPM) is also known as green muscle disease (GMD), Oregon disease (7), and degenerative myopathy of the *Supracoracoideus* (DMS) (4). Due to the similarities in aetiology, DPM is sometimes called the animal model of the human disease, *i.e.* march gangrene (8).

The degeneration is an ischemic, spontaneous necrosis that afflicts mainly the smaller pectoral muscle (*m. pectoralis minor*), in the anatomical nomenclature known as the *supracoracoideus muscle*. The lesion manifests itself in changes in colour and texture. The progression of DPM may be divided into development stages, *i.e.* early and late. Firstly, a muscle has characteristic haemorrhages and a reddish or pink colour (the early stage), later the tissue becomes green or pale grey and shrunken (the late stage) (1). A more detailed classification of the symptoms distinguishes three phases of the disease. The first category (I): an acute inflammatory lesion with numerous haemorrhages; the second category (II): the muscle becomes pink and resembles 'fish flesh'; and the third category (III): progressive degeneration with green necrotic areas (3). The pathological symptoms are found mostly in the central area of the smaller pectoral muscle (8). The aetiology of the disease has not been entirely recognised. It is known that the necrosis results from the specific location of the smaller pectoral muscle that is surrounded by inelastic fascia and the sternum, which do not allow the muscle mass to expand in response to physical activity ("compartment syndrome"). During normal muscle exercise, such as wing flapping, the *supracoracoideus muscle* increases in weight by about

20% (7) or even 25% (3). In a muscle with a limited possibility of swelling the pressure inside increases, causing the occlusion of blood vessels and induces necrosis of the tissue (4, 7). The degeneration has not been observed in wild fowl. It has to be emphasised that the green colour does not result from inflammation, and the changes are the result of ischemic necrosis (7). The green colour probably originates from the transformation of myoglobin under anaerobic conditions.

Deep pectoral myopathy was first observed in turkeys in the USA and was investigated by Harper (5) at Oregon State University. Later, some authors described cases of DPM in meat type chickens (1, 2, 4). In Poland, myopathy was observed in turkey hens, heavy and semi-heavy weight layers at 378 d of age, and in older birds after completing the reproduction cycle (6). Field reports from deboning plants in the USA and South America indicate increased numbers of DPM cases in broilers (2). Taking into consideration the fact that the lesion afflicts valuable parts of the carcasses, and is practically undetectable in live birds, studying the disease and the factors affecting its frequency is extremely important.

The aim of the study was to examine the symptoms of DPM in the central-western part of Poland, and to analyse the influence of factors, such as the age and weight of the birds, that may affect the frequency of the anomaly.

Material and Methods

The investigations were conducted in a slaughter house on broiler chickens at an age of 35-42 d (average weight 2.5 kg); all the birds came from the commercial genotype Ross508. The weight and age of the birds were constantly recorded. The frequency of the incidence of DPM was established (the number of DPM cases x 100%/number of birds subjected to dissection).

The symptoms of DPM in the smaller and greater pectoral muscles were provisionally assessed through macroscopic inspection. Subsequently, changes in the colour of the *supracoracoideus muscles* were examined with the use of a Minolta Chroma Meter CR-200b appliance. The colour was measured within 24 h after slaughter, on the bone side of each fillet, in the area where the lesions appeared. The colour data L*, a*, b* were recorded and analysed, complying with the division into development stages (early, late) and categories (I, II, III). The colour parameters were also measured in the control samples.

Alterations in the texture were assessed with the use of a TA-XT2i texture analyser within 24 h or 48 h after the slaughter of the chickens. Cubes with a cross-section of 5x5 mm and a length of about 20 mm were cut from the muscles; the samples were cut 2-3 times perpendicularly to the muscle fibres. The maximum shear force was measured in Newtons and the shear work was measured in Newtons x sec.

During the experiment, photographic documentation of the examined muscles with DPM symptoms was collected.

All the results were analysed statistically using Statistica 7 software. The statistical analysis included the analysis of Pearson's correlations and the analysis of variance ANOVA (one-way tests of significance and Tukey's test). A significance level of $\alpha=0.05$ and confidence interval of 0.95 were applied for all calculations.

Results

During the study 167,610 birds from 47 farms were examined. Symptoms of DPM were found in 102 carcasses, with the afflicted chickens coming from nine farms. The frequency of DPM cases was estimated at 0.06%. The DPM incidence varied among farms, and ranged from 0% to 1.88%.

The macroscopic examination revealed that 61.4% of necrotic smaller pectoral muscles were afflicted with DPM in the late development stage, that is, tantamount to category III (Fig. 3). Among the fillets classified as the early development stage (Figs 1 and 2), a majority represented category II (I vs. II; 19% vs. 81%). In some cases, the pectoral muscle afflicted with DPM demonstrated one-sidedly an early development stage, while the other fillet was in the late development stage (Fig. 4). Myopathy afflicted the muscles bilaterally in 67% of cases. What is particularly important from the economical point of view is that in 64% of chicken muscles with DPM symptoms changes were also

observed in the *m. pectoralis major* (congestions in the sternum area, haemorrhages) (Fig. 5). This is completely new. In almost all (96.6%) necrotic muscles, an asymmetry and atrophy were found (Fig. 6).

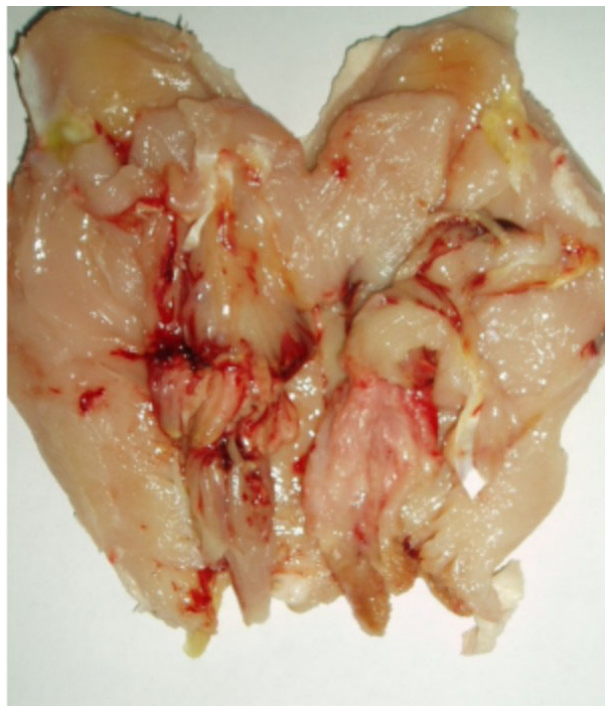


Fig. 1. Early development stage of DPM in chicken - category I.

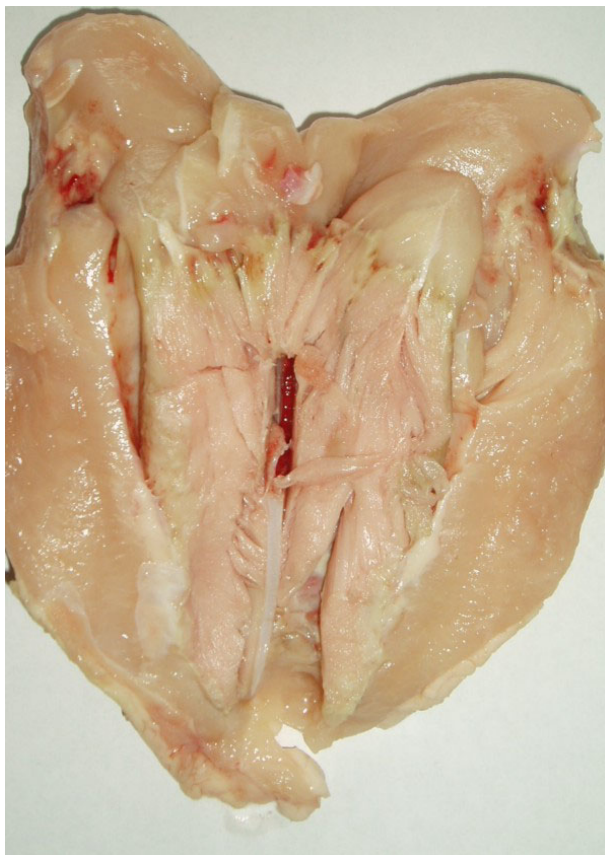


Fig. 2. Early development stage of DPM in chicken - category II.



Fig. 3. Late development stage of DPM in chicken - category III.

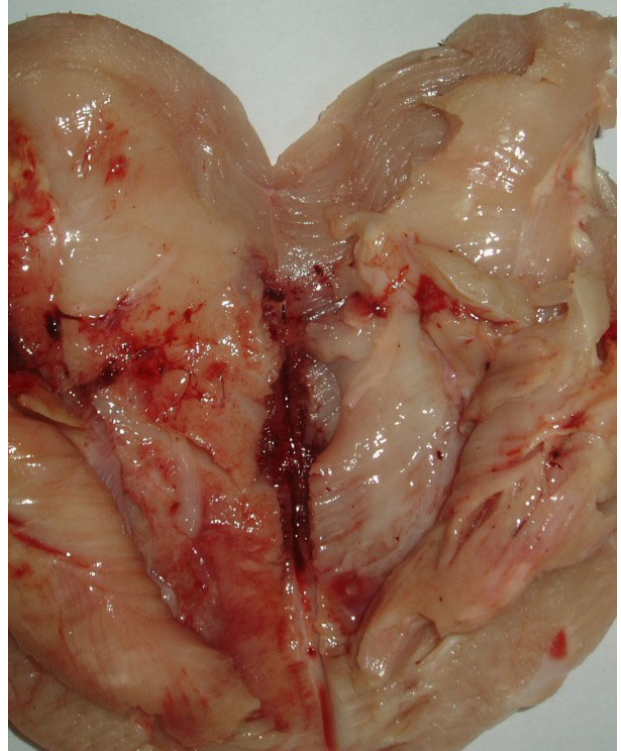


Fig. 5. Changes in the *m. pectoralis major* after cutting of minor pectoral muscles in chicken.



Fig. 4. Late/ Early development stage of DPM in chicken.



Fig. 6. DPM muscle asymmetry and atrophy in chicken.

The preliminary examination revealed significant differences in the texture of the muscles with DMP symptoms. The affected tissue was much tougher and more fibrous in comparison with the control samples. The changes were more observable in muscle with the late development stage of myopathy.

The statistical analysis of the colour parameters revealed significant differences between the development stages and the categories of DMP. The colour parameters for the control samples were established as follows: $L^* = 55.1$, $a^* = 2.28$ and $b^* = 5.6$. The most significant differences in the values were found in terms of parameter a^* (the positive value of parameter a^* was a red colour; the negative value a green colour). The differences in parameter a^* were observed between stages (early, late) and all categories (I, II, III). The highest values (about four times higher than that measured in the control samples) of parameter a^* were conducted in the early stage (early vs. late; 10.8 vs 1.5) and categories I and II (I vs II vs III; 14.2 vs 10.3 vs 1.5). At the late development stage, a wide range of parameter a^* was measured, with values from -4.5 to 7.2. Parameter b^* provides information about the blue (the negative value of b^*) or yellow (the positive value of b^*) colour. During the study, only positive values of parameter b^* were observed; the highest recorded values concerned the tissue in the late development stage (category III) of DPM. The statistical analysis revealed significant differences in the values of parameter b^* between the early and late development stages (10.9 vs 16.3). The division into three categories does not reflect the differences in the values of parameter b^* ; there were no statistically significant differences in parameter b^* between categories I and II. However, they were

considerably lower than the average value of parameter b^* measured for category III of degenerative myopathy. The experiment showed a variation in parameter L^* signifying the lightness (paleness) of tissue. The muscle with DPM symptoms becomes paler in comparison to the control samples (control sample vs early stage vs late; 55.1 vs 57.7 vs 60.4).

The texture analyses revealed that, with the development of ischemic necrosis, the muscle tissue becomes tougher (higher values of maximum shear force and shear work, in the case of the late development stage of myopathy).

The statistical analyses demonstrated that the differences in the texture parameters were significant; for the samples with a cross-section area of 0.25 cm², the average maximum shear force and shear work in the early stage were as follows: 8.2 N and 45.7 N x s; while in the late stage it was 10.7 N and 63.3 N x s (control sample: 3.6 N and 22.7 N*s). The results of the texture analysis confirmed the conclusions from the macroscopic examination that the tissue with DPM symptoms becomes tougher and more fibrous.

During the study the following data were recorded and subjected to statistical analysis: the age and weight of the birds, the weight of the pectoral muscle and of the part afflicted by DPM. The following dependencies were found: the frequency of DPM occurrence increased slightly with an increase in the birds' body weight (positive correlation, correlation coefficient $r_{XY} = 0.27$); and the percentage of afflicted tissue was bigger in the case of heavier pectoral muscles. The statistical analysis revealed that older birds were more at risk of deep pectoral myopathy; a positive correlation, correlation coefficient $r_{XY} = 0.34$.

Table 1
Average values of colour parameters (L^* , a^* , b^*) in chicken muscles with DPM symptoms at different stages and categories

Average values	Development stage		Average values	Category		
	Early	Old		I	II	III
L^*	57.7 ^a	60.4 ^b	L^*	46.1 ^a	59.7 ^b	60.4 ^b
a^*	10.8 ^a	1.5 ^b	a^*	14.2 ^a	10.3 ^b	1.5 ^c
b^*	10.9 ^a	16.3 ^b	b^*	10.6 ^a	10.9 ^a	16.3 ^b
n	167	146	n	24	143	146

a,b,c - different letters in the rows mean statistically significant differences between values (significance level ≤ 0.05)
n - number of colour parameter readings

Table 2
Average values of texture in chicken muscles with DPM symptoms in early and late development stages (categories II and III)

Average values	Development stage (category)		
	Early (II)	Late (III)	Control sample
Shear force (N)	8.2 ^a	10.7 ^b	3.6 ^c
Shear work (N·s)	45.7 ^a	63.3 ^b	22.7 ^c
n	16	35	3

a, b, c - different letters in the rows mean statistically significant differences between values (significance level ≤ 0.05)
n - number of measurements

Discussion

The DPM incidence in the present experiment was established at 0.06%. The value obtained was significantly lower than that estimated by Bianchi *et al.* (1) to be 0.84 %. This discrepancy may result from the different ages and weights of birds. In the experiment conducted by Bianchi, the birds examined were older (47 - 65 d) and heavier (3.14 kg) than those used in the present study, where the birds were slaughtered at an age of 35 - 42 d and the average weight was 2.5 kg. Moreover, the differences and variation in the incidence of DPM among the farms confirms the influence of rearing conditions on myopathy induction, since it is one of the main factors, beside the age and weight of birds, that influences the occurrence of DPM (3).

In the available literature, different divisions of the development phases of degenerative myopathy are found, all of them using colour and texture as the main indicators of changes occurring in the muscle tissue. The macroscopic examination, and that conducted with the use of a professional testing appliance, was to assess those changes. The division of necrotic tissue into two development stages, as suggested by Bianchi *et al.* (1), was justified by the colour analysis, which showed statistically significant differences in the average values of all the colour parameters a^* , b^* , L^* between the early and late development stages. The classification of the changes into three categories (I, II, III), as proposed by Bilgili and Hess (3), was not entirely reflected in the colour analysis. Only in the case of parameter a^* were differences in average values found among all the categories. No statistically significant differences were found in parameter b^* between categories I and II. The intensity of the yellow colour increases in phase III of DPM. In comparison to the control samples, the proportion of the yellow colour in necrotic tenders at all the development stages was significantly higher; however, it was visible in the macroscopic examination only when the necrosis became advanced. The study revealed big discrepancies in the recorded values of parameter a^* at the late development stage of DPM, with values ranging from -4.5 to 7.2. This may result from a high variety of colour changes in the necrotic tissue, classified as an advanced stage of DPM. During the macroscopic examination green, yellowish brown, dark brown, and pale grey tissue colours were observed, all of these cases being considered as the late development stage. In further studies, it is recommended that a more detailed division of DPM symptoms be applied in order to assess the colour changes in more detail.

The texture analysis revealed that the necrotic muscles became tougher with the development of myopathy. At the early stage, the necrotic tissue became twice as tough as the control sample, while at the late stage it is three times as tough. The change in the texture probably results from the occlusion of the blood vessels and the leaking of cellular fluids (9).

The incidence of DPM is increasing, and it affects the most valuable part of the carcasses, *i.e.* the

pectoral muscle. It is of great importance to study the disease and the factors influencing the frequency of myopathy. The progression of the disease is observed in the tissue as colour and texture changes. Since the sequence of pathological events in degenerative myopathy has been recognised and described, it can be an important tool in the recognition of the factors inducing DPM on the farm. In the experiment conducted, most cases of DPM were classified as the late development stage, which may indicate the approximate time of the induction of necrosis. It was concluded that the first (early) stage of the anomaly is maintained for several days after the induction of necrosis (3). The muscles become superficially green after about 9 d, and, at that time, grey areas may be found (9). Formulating a prevention system, based on the scientific knowledge of deep pectoral myopathy, is an issue of increasing concern, since the anomaly results in economic losses. This is especially crucial since, in 64% of the DPM chickens, degenerative lesions were also observed in the *m. pectoralis major*, which is a completely new observation.

In the present experiment the whole pectoral muscle was removed; since the average weight of the pectoral muscle was 0.5 kg, and the price for 1 kg of pectoral muscles is approximately 10.5 Polish Zlotys, the losses for the poultry slaughter house in the case of one carcass with DPM syndrome are estimated at 5.25 Polish Zlotys (€ 1.2).

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