Praca oryginalna *Original paper*

Occurrence and characteristics of chicken breast muscles with DPM symptoms

JACEK KIJOWSKI, EMILIA KUPIŃSKA, ANNA KACZMAREK, JERZY STANGIERSKI, ANNA POPIÓŁ

Department of Food Quality Management, Faculty of Food and Nutrition Sciences, Poznan University of Life Sciences, Wojska Polskiego 28, 60-637 Poznan, Poland

Kijowski J., Kupińska E., Kaczmarek A., Stangierski J., Popiół A.

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Summary

Deep pectoral myopathy (DPM) in m. pectoralis minor is a degeneration occurring in turkeys and broiler chickens. In Poland data were published only on DPM in meat-type turkey breeder hens. However, incidence of DPM was found in chickens slaughtered at week 6-7. The number of such cases is growing with an increased intensification of genetic selection for heavy weight of the breast muscle in chickens. Characteristics of muscles with DPM symptoms in stage I include reddening of muscles with haemorrhages or blood extravasations. In stage II muscle colour from red turns to green, while in the final (III) stage the colour is whitish grey. Texture of DPM muscles is also changed as a result of occurring necrosis. The aim of the study was to determine the frequency of occurrence of DPM symptoms in chickens under Polish conditions, where at present the most commonly used genetic lines are Ross 308 and Cobb 500, slaughtered at the age of 37-45 days. 349 350 chickens from 15 poultry farms were tested. Complete photographic documentation of diagnosed DPM muscles at different stages of this anomaly was prepared at the chicken cutting line in a selected abattoir. Correlations between DPM occurrence and live weight, farm (A-O), poultry house and genetic line were determined. Slaughterhouse economic losses resulting from condemnation of the most valuable muscles were established. The colour of control and DPM muscles was determined in the Hunter scale (L*, a*, b*, ΔE). At the same time analogous traits of m. pectoralis major corresponding to those of tenders with DPM symptoms were analyzed in order to verify whether they underwent any changes. Variation of results was analyzed using Statistica 7.1 software. The following dependencies were found. Frequency of DPM occurrence was dependent on the farm and poultry house, ranging from 0.06 to 0.9%. DPM intensity for Cobb 500 was 2 times higher than that in Ross 308. Atrophy of the minor pectoral muscle was observed. Colour parameter a* best differentiates muscles at different stages of DPM development in relation to the control. For control samples the value of parameter a* was 2.7, for stage I of DPM it was 11.8 (red colour) and for stage II it was – 3.0 (green colour). Based on the analysis of colour, consistency and photographs it may be stated that changes occur also in the major pectoral muscle if the minor pectoral muscle exhibits DPM symptoms. Financial losses for the abattoir slaughtering daily 50 000 chickens due to the condemnation of DPM muscles for the analyzed population of birds amounted to PLN 1047, i.e. approx. EURO 240.

Keywords: chicken broilers, Deep Pectoral Myopathy (DPM), frequency, colour, texture, economic losses

Deep Pectoral Myopathy (DPM) is also referred to as the Green Muscle Disease (GMD), the Oregon disease (7) and degenerative myopathy of the supracoracoideus (4). Degeneration occurs primarily in *m. pectoralis minor* or the „tender", in anatomical nomenclature called *m. supracoracoideus*. Myopathy is an anomaly observed in gallinaceous poultry – chickens and turkeys.

Deep pectoral myopathy is a disease – an anomaly, affecting particularly gallinaceous poultry selected towards intensive pectoral muscle weight gain (7). No DPM cases are recorded in extensive, organic, ecological or „label rouge" animal management systems, in which reared birds have slower muscle weight gain rates and have access to a run from the beginning of their rearing period. This anomaly is not observed in wild fowl even when reared in intensive systems.

In Poland DPM cases were recorded mainly in turkey hens – heavy weight and semi-heavy weight layers aged 378 days, and in older birds after the completion of the reproduction cycle (5, 6). Those authors showed that out of 26 169 examined turkey carcasses disease symptoms were detected in 4 090 animals, i.e. 15.6% all tested birds. These data show that the scale of this phenomenon is economically significant. Reports prepared in poultry

processing plants in the United States and South America indicate that the frequency of the green muscle disease cases is increasing (2).

A considerable variation in the intensity of DPM incidence, described in literature on the subject, results from differences in the age, genetic line and rearing conditions of birds analyzed in individual studies. DPM-type lesions and frequently necrosis in pectoral muscles are initiated during bird rearing. These pathological changes are formed at sudden mobility of birds – particularly wing flapping – which may be caused by stress conditions during rearing (4, 5, 7). The cause of the green muscle disease has not been clarified to date. It is known that necrosis is formed in case of muscle oxygen deficiency during enhanced physical activity of birds (3, 4, 6). An important role in the formation of the anomaly is played by the specific location of the smaller pectoral muscle in the enclosed space, with limited relaxation potential. During exercise, a properly functioning smaller pectoral muscle increasing its volume by 20% (7) or even 25% (3). However, due to the limited physical activity of birds in intensive rearing systems, the fascia surrounding the tender does not acquire elasticity, thus preventing tissue relaxation. Deep pectoral myopathy *in vivo* is practically undetectable and most often is diagnosed only during carcass cutting.

The aim of the study was to determine the effect of live weight of slaughter animals, genetic line and age of chickens, coming from 40 poultry houses in 15 selected farms, on the frequency of DPM incidence in broiler chickens. An additional aim was to compare weight losses of pectoral muscles condemned by the veterinary inspection services due to the incidence of characteristic changes in colour in stages I and II of DPM. Another aim was to conduct instrumental characteristics of colour and texture of minor as well as major pectoral muscles exhibiting symptoms of the anomaly- ischeamic degeneration.

Material and methods

Experimental material consisted of pectoral muscles from broiler chickens, which came from meat lines ROSS 308 and COBB 500 aged from 37 to 45 days and weighing from 1.90 to 2.57 [kg]. The total number of examined chicken carcasses was 349 395. Chickens came from 40 poultry houses in 15 randomly selected farms, denoted from A to O. The number and weight of tenders with DPM changes were determined for each of the 3 stages of disease development and the frequency of deep pectoral myopathy incidence in chickens was calculated for each farm separately, taking into consideration also the different numbers of poultry houses. Weight losses of pectoral muscles caused by DPM incidence were shown and the colour of muscles with DPM symptoms was determined.

Muscle colour determination. A Minolta Chroma-Meter CR 200 photocolorimeter was used. This enables direct reading of values of colour parameters in the Hunter scale. Within 24 h after slaughter values of colour parameters L* a* b* were recorded both for control pectoral muscles, the tenders and superficial muscles, in which no DPM changes were found, and for smaller and greater pectoral muscles

Fig. 1. Symtoms of DPM in broiler chicken, stage I

Fig. 2. Symptoms of DPM in broiler chicken, stage II

Fig. 3. Symptoms of DPM in broiler chicken, stage III

with symptoms of stages I and II. On the basis of thus obtained results the difference in colour ΔE was calculated between pectoral muscles with symptoms of DPM stages I and II and pectoral muscles with no such symptoms using the following formula:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Next from values of colour parameters a* and b* colour saturation C* was calculated using the formula:

$$C^* = \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2}$$

Texture determination. Texture of smaller and greater pectoral muscles was measured in control muscles and in those with DPM symptoms using a TA-XT2i texture analyser Stable Micro System. Measurements were taken within 24 h after slaughter of chickens. Cubes with a cross-section of 5 × 5 mm and length of 20 mm were cut from muscles. Each sample was cut 2-3 times perpendicularly

to grain. Maximum shear force was measured in Newtons and shear work was measured in Newton × sec.

Statistical analysis. Results were analyzed statistically using Statistica 7.1 software. In the statistical elaboration of results the analysis of linear regression, analysis of Pearson's correlation and the analysis of variance were applied: one-way tests of significance and Tukey's test. All calculations were performed for significance level $\alpha = 0.05$ and confidence interval of 0.95.

Results and discussion

Macroscopic examination indicated, that the first stage of DPM (I) is characterized by an intensive, red-pink colour of the tender affected by DPM symptoms, frequently connected with the presence of blood extravasations and blood clots in vessels (fig. 1). In the second stage (II) an intensive green muscle colour is observed (fig. 2). In the third stage (III) the tender undergoes necrosis and becomes grey-white-green in colour (fig. 3). This study revealed, that the DPM degenerative symptoms also concerned *m. pectoralis major* (fig. 4).

Fig. 4. Changes in *m. pectoralis major* in broiler chicken with the DPM symptoms

Statistical analysis showed that live weight of slaughter birds has a significant effect on the frequency of DPM (fig. 5). Regression analysis indicated a statistically significant and positive linear dependence between the frequency of DPM incidence (stages I, II and III analyzed jointly) and live weight of slaughter animals. This dependence is linear and according to this relationship if the weight of slaughter animals increases by 0.1 [kg], then the frequency of DPM in broiler chickens is expected to increase by 0.03438%.

However, no statistically significant difference of the intensity of DPM incidence was found depending on the age of chickens. This may have been caused either by a slight age interval between analyzed chickens, amounting to 37-45 days, or by an insufficient number of measurements. On the other hand, a trend was observed for DPM frequency to increase with the age of chickens in terms of the increasing number of days. Moreover, the analysis showed that the genetic line of poultry has a statistically significant effect on the incidence of myopathy of tenders (fig. 6). In case of chickens from meat breed COBB 500 an almost two-fold higher percentage of pectoral muscles with DPM lesions was recorded than in case of breeding line ROSS 308. The mean frequency of DPM incidence in broiler chickens of breeding line ROSS 308 was 0.15% and in case of breeding line COBB 500 it was 0.29%. The percentage of DPM incidence in chickens of breeding line COBB 500 ranged from 0.074% to 0.915%, whereas in breeding line ROSS 308 the range was 0.027--0.603%. A similar mean frequency of DPM incidence of 0.35% was determined in studies conducted in Italy on breeding line COBB 500 (1).

Tab. 1. Frequency of deep pectoral myopathy (DPM) in per cent of tested chicken influenced by farm (broiler management)

Farm	Number of tested birds	Frequency (%)
I	75 765	0.104[a]
C	77 763	0.108[a]
F	4302	0.128[ab]
K	5091	0.167[ab]
L	10 156	0.167[ab]
D	4348	0.172[ab]
N	7895	0.184[ab]
E	19 730	0.190[ab]
A	33 957	0.232[ab]
O	7501	0.235[ab]
J	8379	0.274[ab]
B	54 513	0.287[b]
G	14 847	0.323[b]
M	9515	0.380[b]
H	15 633	0.682[c]
Total number of tested birds 349 395		

Explanation: a, b, c – different letters in column indicate statistical significant differences ($\alpha \leq 0,05$)

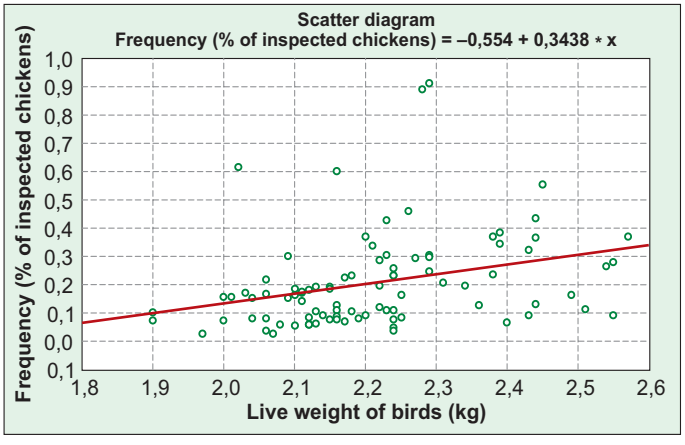

Fig. 5. Frequency of myopathy (DPM) in the minor pectoral muscle of tested chicken influenced by live weight of birds (%)
$R = 0,30995$; $R^2 = 0,09607$; the standard error of estimate: 0,15969; significance level $p < 0,00295$; confidence interval: 0,95

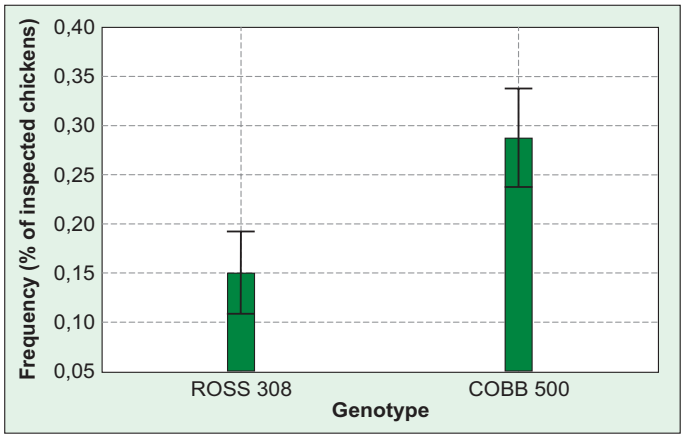

Fig. 6. Frequency of deep pectoral myopathy (DPM) in the minor pectoral muscle of tested chicken influenced by genotype (%)
Explanation: I the lowest significant difference at $\alpha \leq 0,05$

Statistical analysis showed a significant dependence between the frequency of DPM in chickens and their farm of origin (tab. 1). The highest intensity of DPM incidence was recorded in farm H. Chickens coming from that farm were of a bigger weight, which – as it was confirmed statistically – significantly affects the occurrence of pectoral muscle myopathy. Moreover, chickens coming from farm H were animals from genetic line COBB 500, in which DPM is observed more frequently, as it was also confirmed by the results of the analysis. In turn, the best material due to the low incidence of DPM may be pectoral muscles of chickens coming from farm I, as well as farm C. These chickens were mostly from meat line ROSS 308, in which – as it results from the analysis of variance – the percentage of changed pectoral muscles in broiler chickens was statistically significantly lower. Moreover, chickens coming from farms I and C had relatively low weights. However, when determining the causes of DPM incidence in broiler chickens coming from different farms and poultry houses, we need to take into consideration first of all different methods of bird handling, different intensities of stressors causing wing flapping or flightiness, as well as different organization solutions adopted in the management of tested farms.

Mean frequency of DPM incidence for all analyzed chickens was 0.207%, ranging from 0.027% to 0.915%. This mean and this range are smaller in comparison to the results recorded in a study by Bianchi et al. (1), since mean incidence levels of tender myopathy in that publication was estimated at 0.84%. Also the range of DPM incidence was much higher and more varied, as it ranged from 0.0 to 16.7%. Such a large difference in mean frequency of DPM incidence may have resulted from the age as well as weight of chickens, on which the occurrence of DPM is dependent. Mean weight of chickens examined by Bianchi et al. (1) was 3.14 kg and birds were slaughtered at the age of 47 to 65 days, whereas in our study the weight of chickens ranged from 1.90 to 2.57 kg, while their age was 37 to 45 days, respectively.

Table 2 presents mean values for colour parameters L* a* b* for control, minor pectoral muscles and major pectoral muscles as well as muscles with symptoms of DPM stages I and II. Parameter L* for *m. pectoralis minor* exhibiting symptoms of DPM stage I did not differ from that of control samples. Parameter a* was significantly higher than its value for the control sample and it took positive values, which corresponds to an increase in the intensity of red colour. Values of parameter b* were also positive and higher than values of this parameter for the control muscle. Thus it may be stated that the intensity of red colour in DPM stage I is also accompanied by an increase in the intensity of yellow colour.

Taking into consideration the results given in tab. 2 and the analysis of variance we may conclude that tenders with symptoms of DPM stage II had higher values of parameter L* than those observed for the control sample. In turn, negative values were recorded for parameter a*. This shows a marked intensity of green colour. In contrast, values of parameter b* were higher than those for this parameter in the control pectoral muscle, which indicates the intensity of yellow colour. However, when comparing values of parameter b* for DPM stages I and II we may see that the intensity of yellow colour in stage II was bigger.

Values of parameter a* for *m. pectoralis major*, corresponding to those of *m. pectoralis minor* with symptoms of DPM stage I, did not differ from those of the control samples (tab. 2). In contrast, values of parameter b* were higher than values of parameter b* for the control sample. Based on the analysis of values for colour parameters L* a* b* for pectoral muscles exhibiting symptoms of DPM stage I we may conclude that a change in colour occurs primarily in *m. pectoralis minor*. In turn, in *m. pectoralis major* a change in colour is slight and hardly perceptible unless using instrumental measurement of colour parameters.

It may also be stated on the basis of measurements of colour parameters a* b* for major pectoral muscles, that these muscles exhibit changed colour properties in relation to control muscles with no DPM symptoms. Thus, both measurements of colour parameters L* a* b* and photographic documentation indicate that DPM lesions apart from tenders concern also major muscles.

Summarized the results of colour characteristic, the most important parameter assessing muscle colour with DPM symptoms is the a* value, as it differentiates occurring changes most markedly (fig. 7). This parameter may take negative values and then it corresponds to green colour, if it is 0 this means grey colour, while a positive value refers to red colour. Figure 3 presents variation in values of parameter a* for minor and major pectoral muscles depending on the analyzed stage of the disease. A large difference was found in means for a* in stages I and II.

In turn, means of parameter a* for the tender and the control major muscle do not differ significantly. The a* value for *m. pectoralis major* with DPM stage II differs significantly from that of the control and from that for DPM stage I. It was found that the highest positive value of parameter a* was recorded for tenders in DPM stage I, which shows definitely the highest intensity of red colour. In turn, the lowest (negative) value was

Tab. 2. Mean values of colour parameters in Hunter scale for the breast muscle of chickens with the DPM symptoms

DPM	*M. pectoralis minor*					*M. pectoralis major*				
	L*	a*	b*	ΔE	C*	L*	a*	b*	ΔE	C*
Control (n =16)	51.73^{a}	2.73^{a}	1.13^{ab}	–	–	53.95^{ab}	2.6^{a}	0.63^{a}	–	–
I stage (n = 150)	51.31^{a}	11.81^{d}	5.43^{d}	11.06^{c}	13.09^{c}	51.56^{a}	2.6^{a}	2.54^{b}	4.84^{a}	3.82^{a}
II stage (n = 210)	60.60^{c}	-3.04^{b}	14.18^{e}	17.33^{d}	14.62^{d}	56.05^{b}	0.91^{c}	4.48^{c}	5.71^{b}	4.69^{b}

Explanation: a, b, c, d, e – different letters in column indicate statistical significant differences between both muscles ($\alpha \leq 0,05$)

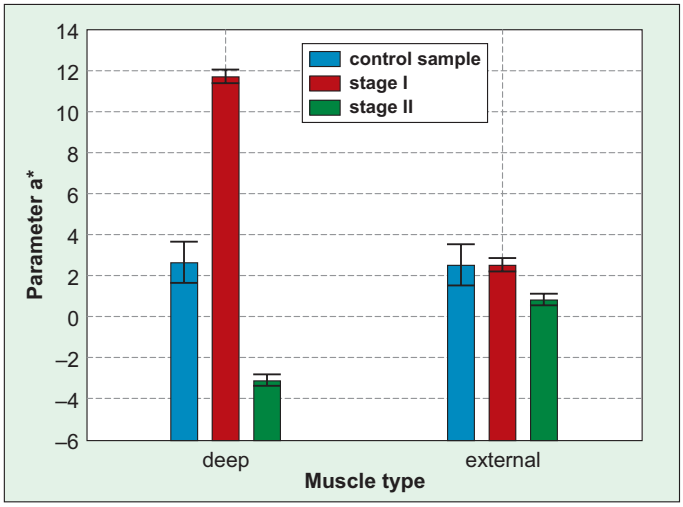

Fig. 7. Values of colour parameter a* influenced by stage of DPM for *m. pectoralis minor* (deep) and *m. pectoralis major* (external) breast muscle of tested chicken
Explanation: as on fig. 6.

found for *m. pectoralis minor* in DPM stage II, when it exhibited a high intensity of green colour.

It was also found that higher values ΔE are observed in tenders rather than in greater pectoral muscles, i.e. myopathy pertains particularly to tenders of broiler chickens and only slight changes are found in major pectoral muscles.

Statistical analysis of colour saturation showed that higher values of parameter C* are found in DPM stage II. It was also found that higher values of colour saturation are recorded for tenders rather than major pectoral muscles. Thus it shows that a deeper colour, a higher proportion of pure chromatic colour in overall perception are observed in tenders with symptoms of DPM stages I and II than in major pectoral muscles.

Changes in texture were determined in raw *m. pectoralis minor* with DPM symptoms and a corresponding *m. pectoralis major* in stage II when it changed its colour to green in relation to the control muscles (tab. 3). It was found that both shear force and shear work of uniformly prepared samples were over three times higher than those for the control sample. Hardening is a consequence of lesions occurring in advanced muscle necrosis. In turn, significant changes were found in the consistency of greater pectoral muscles, corresponding to carcasses with evident DPM symptoms. Their hardness (shear force and shear work) increased by approx. 30% in relation to normal muscles. It is yet another piece of evidence for the occurrence of these changes also in *m. pectoralis major*.

Tab. 3. Mean values of texture parameters for the breast muscles of chickens with the DPM II stage symptoms

DPM	*M. pectoralis minor*		*M. pectoralis major*	
	Strenght (N)	Work (N × s)	Strenght (N)	Work (N × s)
Control (n = 24)	4.7^{a}	29.2^{a}	11.4^{a}	72.3^{a}
II Stage (n = 24)	16.4^{b}	94.8^{b}	18.2^{b}	102.3^{b}

Explanation: a, b in column – $\alpha \leq 0{,}05$

The percentage weight loss of pectoral muscles as a result of DPM stages I and II was calculated in this study. The finding from these experiments that the mean incidence of DPM is 0.207% slaughtered population was adopted as an assumption here. It is a relatively low level in comparison to those reported in other studies. Thus it was assumed that for an abattoir slaughtering 50 000 chickens daily the losses will amount to: 15.31 kg tenders × PLN 16/kg = PLN 245. This hold true in a situation when the veterinary inspection services condemn only smaller pectoral muscles (tenders), which are to be utilized. Since there are no binding regulations in the EU defining how to proceed at abattoirs/processing plants with muscles exhibiting DPM symptoms, several plants in Poland treats whole pectoral muscles as condemned and subjects them to waste utilization. Then losses are higher and amount to PLN 245 + 76.39 kg (greater pectoral muscles) × PLN 10.5 = PLN 802, which total is PLN 1047, i.e. approx. EURO 240.

Conclusions

1. The frequency of myopathy of *m. pectoralis minor* in chickens is affected by the weight of birds, breeding line as well as the farm and the poultry house, from which they originate. A large variation in the intensity of DPM incidences is the effect first of all of the varied chicken management methods adopted in individual poultry houses.

2. The most important parameter for the assessment of colour both in case of types of pectoral muscles – *m. pectoralis minor* and *m. pectoralis major* in broiler chickens with DPM symptoms is parameter a*. Values of this parameter best characterize the variation in colour of tested muscles.

3. DPM changes occur not only in *m. pectoralis minor*, but also in corresponding *m. pectoralis major* and then have typical traits for stage I of DPM. Economic losses for slaughterhouse incurred as a result of DPM are growing, especially in the case that greater breast muscles are afflicted by ischeamic degeneration.

4. Veterinary and sanitary regulations are required to define the procedures concerning the handling of muscles exhibiting DPM symptoms.

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Author's address: prof. zw. dr hab. Jacek Kijowski, Poznan University of Life Sciences, ul. Wojska Polskiego 31, 60-624 Poznań; e-mail: kijowski @up.poznan.pl

Kijowski J., Kupińska E., Kaczmarek A., Stangierski J., Popiół A.

Występowanie i charakterystyka mięśni piersiowych kurcząt z objawami DPM

Streszczenie

Miopatia mięśnia piersiowego mniejszego (DPM) (*m. pectoralis minor*) jest degeneracją występującą u indyków i kurcząt brojlerów. W Polsce opublikowano jedynie dane o DPM u indyczek, niosek typu ciężkiego. Stwierdzono jednakże przypadki DPM u kurcząt ubijanych w 6.-7. tygodniu życia. Ich liczba narasta wraz ze zwiększeniem intensyfikacji selekcji genetycznej w kierunku dużej masy mięśnia piersiowego. Charakterystyczne dla mięśni z objawami DPM jest w I fazie zaczerwienienie mięśnia z objawami wybroczyn krwawych i wynaczynień, w II fazie następuje przechodzenie barwy czerwonej w zieloną, a w końcowej (III fazie) w biało-szarą. Również tekstura mięśni DPM ulega zmianie w wyniku zachodzącej martwicy. Celem badań było ustalenie stopnia natężenia występowania objawów DPM u kurcząt w warunkach polskich, gdzie obecnie najczęściej użytkowane są linie genetyczne Ross 308 oraz Cobb 500 i ubijane w wieku od 37 do 45 dni życia. Badania przeprowadzono na 349 350 kurczętach z 15 ferm. Dokonano pełnej dokumentacji fotograficznej stwierdzonych przypadków mięśni DPM w różnych stadiach rozwoju anomalii na linii rozbioru kurcząt w wybranej rzeźni. Określono zależność występowania DPM od masy żywej, fermy, kurnika i linii genetycznej. Ustalono straty w ubojni z powodu niezdatności do użycia na cele spożywcze najcenniejszych mięśni. Określono barwę mięśni kontrolnych oraz DPM w skali Huntera (L*, a*, b*, ΔE). Analizowano też równolegle cechy mięśni piersiowych większych (*m. pectoralis major*) odpowiadających mięśniom piersiowym mniejszym z objawami DPM, w celu ustalenia, czy uległy jakimkolwiek zmianom. Dokonano analizy statystycznej wyników. Stwierdzono następujące zależności. Częstotliwość występowania DPM zależna była od fermy i kurnika i wynosiła od 0,06% do 0,9%. Natężenie DPM dla Cobb 500 było 2 razy większe niż dla Ross 308. Stwierdzono atrofię m. piersiowego mniejszego. Parametr barwy a* najlepiej różnicuje mięśnie kontrolne i w różnych stadiach DPM. Dla kontrolnych prób wartość parametru a* wynosiła 2,7 dla I stadium DPM 11,8 (barwa czerwona), a dla II – 3,0 (barwa zielona). Na podstawie oceny barwy i konsystencji oraz dokumentacji fotograficznej stwierdzono, że zmiany następują również w mięśniu piersiowym większym, jeśli m. piersiowy mniejszy wykazuje objawy DPM. Wyliczono stratę masy mięśni piersiowych jako rezultat I i II stadium DPM. Przyjęto do wyliczeń ustalone w tych badaniach średnie natężenie występowania anomalii DPM na poziomie 0,207% ubijanej populacji drobiu. Jest to stosunkowo niski poziom w relacji do danych podawanych w innych źródłach. Ustalono, że straty dla rzeźni ubijającej dziennie 50 000 kurcząt wyniosą 15,31 kg mięśnia piersiowego mniejszego (potoczna nazwa – polędwiczka) × PLN 16/kg = 245 PLN. Takie wyliczenie jest prawidłowe, gdy urzędowa służba weterynaryjna nadzorująca ubojnię zaleca utylizację tylko polędwiczki. Ponieważ nie ma regulacji prawnej w przepisach UE ani procedury postępowania w rzeźniach lub przetwórniach drobiu w przypadku ustalenia obecności mięśni z objawami degeneracji niedokrwiennej DPM, niektóre z zakładów produkcyjnych w kraju traktują całe mięśnie piersiowe jako niezdatne do spożycia i utylizują je. Wówczas straty ekonomiczne są wyższe i wynoszą: PLN 245 + 76,39 kg (m. piersiowy większy) × PLN 10,5 = PLN 245 + PLN 802, co daje łącznie = PLN 1047.

Opisy rycin i tabel:

Ryc. 1. Objawy DPM u kurcząt brojlerów, faza I
Ryc. 2. Objawy DPM u kurcząt brojlerów, faza II
Ryc. 3. Objawy DPM u kurcząt brojlerów, faza III
Ryc. 4. Zmiany w m. piersiowym większym kurcząt brojlerów z objawami DPM
Ryc. 5. Częstotliwość występowania miopatii m. piersiowego mniejszego (DPM) badanych kurcząt w zależności od żywej masy ptaków (%)
R = 0,30995; R^2 = 0,09607; błąd standardowy oszacowania: 0,15969; poziom istotności p < 0,00295; przedział ufności: 0,95
Ryc. 6. Częstotliwość występowania miopatii m. piersiowego mniejszego (DPM) badanych kurcząt w zależności od genotypu (%)
Objaśnienie: I najmniejsza istotna różnica na poziomie $\alpha \leq 0,05$
Ryc. 7. Wartości parametru barwy a* w zależności od fazy DPM m. piersiowego mniejszego oraz m. piersiowego większego badanych kurcząt
Objaśnienie: jak na ryc. 6.
Tab. 1. Częstotliwość występowania miopatii m. piersiowego mniejszego (DPM) badanych kurcząt w zależności od fermy (sposobu zarządzania kurczętami) (%)
Objaśnienie: a, b, c – różne litery w kolumnach oznaczają różnice istotne statystycznie ($\alpha \leq 0,05$)
Tab. 2. Średnie wartości parametrów barwy w skali Huntera mięśni piersiowych kurcząt z objawami DPM
Objaśnienie: a, b, c, d, e – różne litery w kolumnach oznaczają różnice istotne statystycznie między wartościami średnimi dla poszczególnych parametrów barwy, jednocześnie analizowane dla mięśni piersiowych mniejszych i większych ($\alpha \leq 0,05$)
Tab. 3. Średnie wartości parametrów tekstury mięśni piersiowych kurcząt z objawami II stadium DPM
Objaśnienie: a, b w kolumnach – $\alpha \leq 0,05$