Research Note: Quality parameters of turkey hens breast fillets detected in processing plant with deep pectoral myopathy and white striping anomaly

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ABSTRACT The increase in the consumption of poultry meat intensified production, which allowed the emergence of myopathies associated with broiler and turkey meat. The aim to examine possible quality alterations in the 240 *Pectoralis major* muscle (breast fillets) from carcasses of turkey breeder hens. Regarding DPM, 120 samples of breast fillets from turkey of the Nicholas strain with *Pectoralis minor* muscle together were selected according to the occurrence of the myopathy in the *Pectoralis minor* muscle (tender), as follows: DPM score 2 (n = 40), DPM score 3 (n = 40), and a control group unaffected by DPM, score 0 (n = 40). Then, different 120 samples, from the same flock of birds, were selected according to White Striping (**WS**) anomaly in the *Pectoralis major* muscle (breast fillets), considering the degree of severity of the striations apparent in the muscle, as follows: moderate (n = 40), severe (n = 40) and a control group (normal) without the presence of WS anomaly (n = 40), with set up as a completely randomized design with 3 treatments for DPM and WS. We evaluated in meat of turkey breeder hens color, water-holding capacity (**WHC**), cooking loss (**CL**), shear force (**SF**), sarcomere length (**SL**) and total, soluble and insoluble collagen contents. The color parameters lightness (L*), redness (a*), and yellowness (b*) of turkey breeder hens breast fillets were altered by the occurrence of DPM and WS and as except CL, there were a difference for WHC and SF ($P < 0.05$). Significant differences were observed for sarcomere length ($P < 0.05$) between fillets without myopathies and with DPM Score 2 and 3 too. Higher values of total collagen (%) were observed for the most severe category of involvement for both myopathies. The DPM and WS affect the color and in a partial reduction texture of the breast fillets meat of turkey breeder hens and this may have a negative economic impact on the meat industry, because these are the main points evaluated by the consumer, in the most value commercial cut.

Key words: collagen, cooking loss, sarcomere length, shear force, water-holding capacity

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INTRODUCTION

The last decades have witnessed an increase of consumer preference for poultry meat over other types of muscle foods. This increase in the consumption of poultry meat intensified production, which allowed the emergence of myopathies associated with broiler and turkey meat. These myopathies include Deep Pectoral Myopathy (**DPM**), White Striping (**WS**), and Wooden Breast (**WB**), among others. The most studied myopathies and anomalies in broiler meat are White Striping and Wooden Breast and they are even less studied in turkeys. Therefore, further studies on their possible effects to the quality of the turkey meat are still required, as well as additional studies of how deep pectoral myopathy, which occurs in the *Pectoral minor* muscles, could affect the quality of attached breasts fillets.

Although the mechanism by which high growth rates in modern broilers trigger myopathies is not yet fully known, it is already clear that heavier birds have a higher incidence of muscular diseases (Lorenzi et al., 2014), making them an important objective of research. However, new obstacles to the industry, such as the appearance of DPM and WS, in different degrees of severity, have increased the need for studies on the physical, chemical, and histological changes that genetic

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progress can introduce to hens and matrices (Petracci and Cavani, 2011).

DPM is characterized by muscle degeneration, which causes necrosis and atrophy, especially in the *Pectoralis minor* or *supracoracoideus* muscle (tender). Its lesions can affect both portions of the *Pectoral minor* muscles, being uni- or bilateral, and vary in color, evolving from a pinkish, blood-like appearance to a grayish-green discoloration (Bilgili and Hess, 2008). The occurrence of DPM depends on factors such as rearing conditions, age, weight, sex, and genetic strain (Kijowski et al., 2014) and it is accentuated in commercial turkeys, due to the lack of exercise of their pectoral muscles, due to the inactivity of the birds on the farms.

The WS anomaly is characterized by the occurrence of white striations viewed parallel to the muscle fibers, especially in the ventral surface (skin side) of the *Pectoralis major* muscle (breast fillet), and may present varying degrees of severity, being classified as normal (**NORM**), moderate (**MOD**), and severe (**SEV**). This anomaly is directly associated with heavier and/or higher growth rate poultry (Kuttappan et al., 2012).

Appearance and texture are the two most important quality attributes for poultry meat. Poultry meat color is a critical food quality attribute and is important for both type of consumers on selection of a raw meat product in the marketplace. After the purchase, the most important point is the meat texture that will be perceived on consumption time and could affect the product final quality assessment. These two attributes will be decisive for the consumer, as one (color) directly impacts the choice, purchase decision and the other (texture) at customer loyalty.

Thus, the present study proposes to examine the quality parameters of color and texture of the *Pectoralis major* muscle (breast fillets) from carcasses of turkey breeder hens affected by DPM in *Pectoralis minor* (tender) muscle in their different degrees (score 2, score 3 and control group unaffected or score 0) and WS in *Pectoralis major* muscle in their different degrees (moderate, severe, and control group unaffected).

MATERIALS AND METHODS

Sample Collection

All samples were selected at 3-h postmortem from a commercial turkey slaughter plant in the south region of Brazil following the procedures adopted by the processing plant. The turkeys were slaughtered according to the standardized industrial practice consisting of electrical stunning, bleeding, scalding, plucking, evisceration, chilling, and deboning. Samples were harvested from turkey breeder hens of the Nicholas strain at disposal age (450 d), at an average weight of 13.0 kg. For the classification step, breast meat samples, *Pectoralis major* muscle with *Pectoralis minor* muscle together were selected at random on the slaughter line according to the occurrence of the myopathy in the *Pectoralis minor* muscle (tender), DPM score 2 (n = 40), DPM score 3 (n = 40), and a control group unaffected by DPM, score 0 (n = 40). The samples were classified as to the degree of severity of DPM in the Pectoralis minor muscle before the process of separating the two breast muscles and removed that only the affected part of the carcass should be discarded.

In accordance with the methodology adopted by Bilgili and Hess (2008), samples exhibiting well-defined lesions on the *Pectoralis minor* (tender) muscle were classified as DPM score 2; some of these lesions were surrounded by a clear hemorrhagic ring. Those which showed progressive degeneration of the *Pectoralis minor* muscle, with the damaged muscle tissue having a greenish appearance, were classified as DPM score 3 (Figure 1). After this classification step, the *Pectoralis minor* muscle of each was discarded and samples of the remaining *Pectoralis major* muscle (breast fillets) were sent for quality analyses.

Then, 120 samples, from the same flock of birds, were selected according to WS anomaly in the *Pectoralis major* muscle (breast fillets) for the macroscopic classification, considering the degree of severity of the striations apparent in the muscle, as follows: moderate (n = 40), severe (n = 40), and a control group (normal) without the presence of WS anomaly (n = 40), according to the methodology used by Kuttappan et al. (2012) (Figure 2).

The MOD degree classification was given to fillets that exhibited white striations with a thickness inferior to 1 mm, but visible on the surface of the muscle. The fillets showing white striations, parallel to the muscle fibers, with a thickness greater than 1 mm, easily visible on the surface of the breast fillet, were classified as SEV. The fillets that did not show white striations were classified as NORM.

Meat texture and color analyzes were performed immediately after the collection and classification of the DPM myopathy and the WS anomaly in the *Pectoralis*

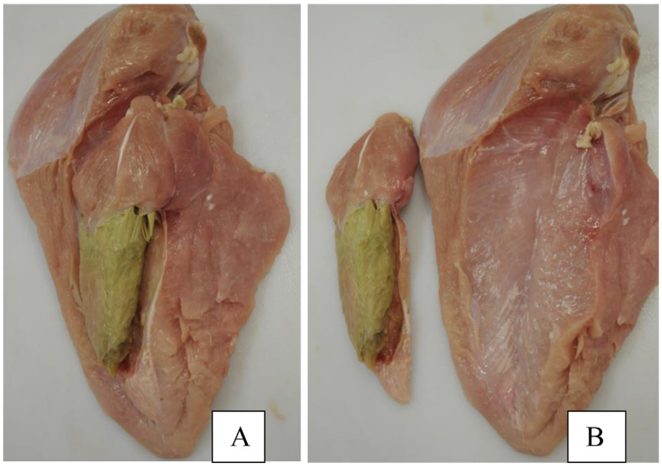

Figure 1. Classification of the deep pectoral myopathy (DPM) according to the degree of severity score 3 of the *Pectoralis minor* muscle. (A) Breast complex: *Pectoralis major* muscle and *Pectoralis minor* muscle. (B) Separate muscles: use only *Pectoralis major* muscle for analyses. Source: the authors.

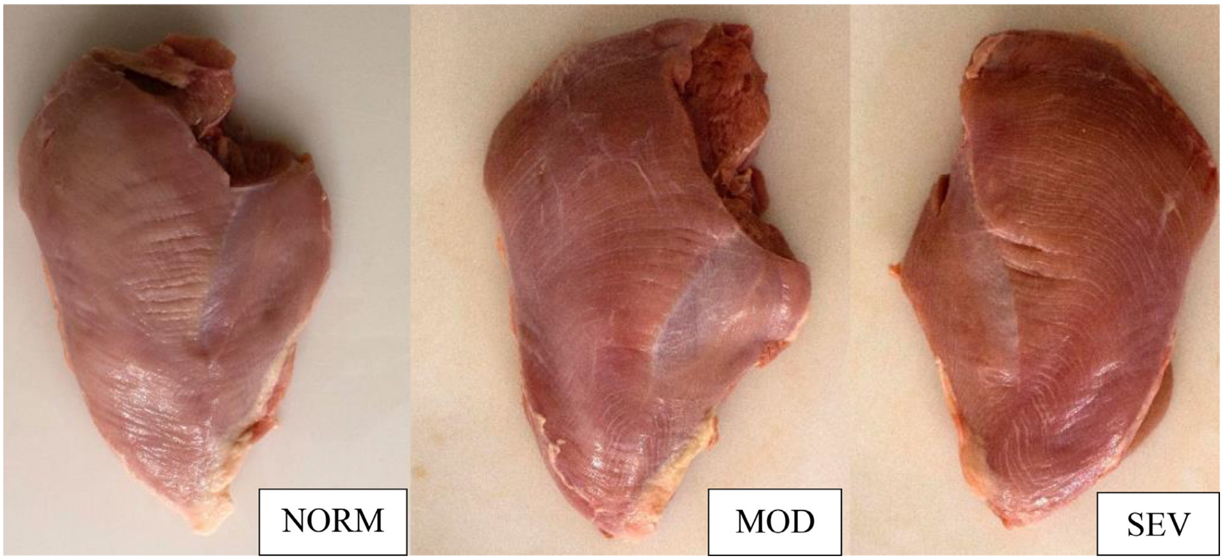

Figure 2. Classification of the White Striping anomaly according to the degree of severity (normal- NORM, moderate - MOD and severe - SEV) of the apparent white striations in the muscle (breast fillets). Source: the authors.

major muscle (breast fillet) after the separation and disposal of the *Pectoralis minor* muscle (tender).

Laboratory Analyses

Color was determined in the ventral (skin side) and dorsal (bone side, in contact with the *Pectoralis minor* muscle) surfaces of the *Pectoralis major* muscle, both at three points and the three averages of each were used. Meat color was determined using a colorimeter (Minolta Chrome Meter CR-400, Konica Minolta Sensing, Inc., Osaka, Japan), which employs the CIELAB system [lightness (L*), red intensity (a*), and yellow intensity (b*)].

Water-holding capacity (**WHC**) was determined with 2-g sample of the *Pectoralis major* muscle (breast fillets) and Cooking loss (**CL**) was determined from breast fillets were weighed, packed and cooked in a water-bath at 85°C for 30 min. Samples were weighed, packed and cooked in a water-bath at 85°C for 30 min. After cooling at room temperature, samples were from the CL analysis, with area equal to 1 cm^2, were used to determine shear force (**SF**) to a Warner-Bratzler device coupled to a Texture Analyzer (TA-XT2i, Stable Micro Systems, LTD., Godalming, UK).

Sarcomere length was determined by phase-contrast microscopy with 0.5-g sample was homogenized with 30 mL of a 50:50 KCl (0.08 mol/L) and KI (0.08 mol/L) solution. Total, soluble and insoluble collagen contents according to the methodology proposed adapted by Carvalho et al. (2021), were quantified by determination of the amino acid hydroxyproline with 5 g of frozen raw turkey breast fillet was weighed into 50 mL falcon tubes and 20-mm distilled water was added.

Statistical Analysis

The experiment was set up as a completely randomized design with 3 treatments (control group - unaffected by DPM − score 0; and degrees of severity - DPM scores 2 and 3) of 40 samples each for DPM, 120 total samples. And the same for WS anomaly, completely randomized design with 3 treatments (control group − unaffected by WS- NORM, MOD, and SEV) of 40 samples, 120 total samples. Data were analyzed using the One-Way ANOVA procedure of SAS (2002−2003) software (Statistical Analysis System; SAS Institute Inc, Cary, NC). Results were subjected to analysis of variance, and, in case of significance, means were compared by Tukey's test with significance defined as $P < 0.05$.

RESULTS AND DISCUSSION

Compared to score 0 meat, breast fillets from carcasses affected by DPM (scores 2 and 3) were paler (L*), ventral ($P < 0.0014$), and dorsal ($P < 0.0050$), respectively; more yellowish (b*), ventral ($P < 0.0001$), and dorsal ($P < 0.0050$), and redder (a*), ventral and dorsal ($P < 0.0001$). And this was also observed in the breast fillets affect by WS (MOD and SEV), for both the ventral and dorsal surfaces, which were paler (L*), ventral ($P < 0.0001$) and dorsal ($P < 0.0001$), respectively; more yellowish (b*), ventral ($P < 0.0134$), and dorsal ($P < 0.0001$), and redder (a*), ventral and dorsal ($P < 0.0001$) than the NORM samples (Table 1).

The color parameters of breasts fillets were altered by the occurrence of DPM and WS, with the change even detectable in MOD/score 2 cases, which did not differ ($P > 0.05$) from SEV/score 3 to Lightness (L*), redness (a*) and yellowness (b*) of the ventral and dorsal surfaces. Turkey breast fillets affected by myopathy/anomaly (DPM and WS) showed higher Lightness (L*), redness (a*), and yellowness (b*) when compared to breast fillets absent of any myopathy for the ventral and dorsal surfaces.

Soglia et al. (2018), when studying the effect of WS on turkey breast meat quality, reported that the quality traits and technological properties of the WS muscles

Table 1. Meat quality parameters of the turkey breeder hens breast fillets affected by the deep pectoral (DPM) myopathy and white striping (WS) anomaly.

	DPM Score			
	0	2	3	*P*-value
L* (ventral)	54.87 ± 2.11[B]	57.70 ± 3.01[A]	57.75 ± 2.45[A]	0.0014
a* (ventral)	2.90 ± 0.56[B]	4.00 ± 0.81[A]	4.07 ± 0.64[A]	<0.0001
b* (ventral)	1.75 ± 0.88[B]	2.88 ± 1.29[A]	3.44 ± 1.43[A]	0.0024
L* (dorsal)	52.87±2.32[B]	54.95 ± 2.38[A]	55.99 ± 3.65[A]	0.0050
a* (dorsal)	3.95 ± 1.15[B]	5.39 ± 0.95[A]	5.53 ± 1.10[A]	<0.0001
b* (dorsal)	0.97 ± 0.77[B]	2.71 ± 1.07[A]	2.52 ± 0.86[A]	<0.0001
WHC	74.17 ± 2.30[A]	71.84 ± 2.43[B]	72.01 ± 2.51[B]	0.0041
CL	21.155 ± 4.55	18.819 ± 3.33	20.903 ± 2.68	0.1082
SF	20.380 ± 4.86[A]	19.628 ± 3.78[A]	17.013 ± 2.25[B]	0.0163
Total collagen (%)	0.298 ± 0.08[B]	0.432 ± 0.04[A]	0.510 ± 0.14[A]	0.0002
Soluble collagen (%)	0.023 ± 0.09[B]	0.015 ± 0.06[B]	0.036 ± 0.01[A]	<0.0001
Insoluble collagen (%)	0.278 ± 0.04[B]	0.428 ± 0.07[A]	0.524 ± 0.14[A]	<0.0001
Sarcomere length (μm)	1.92 ± 0.05[B]	2.01 ± 0.04[A]	1.99 ± 0.03[A]	<0.0001
	WS Score			
	NORM	MOD	SEV	*P*-value
L* (ventral)	54.27 ± 1.82[B]	63.19 ± 2.45[A]	64.23 ± 2.92[A]	0.0001
a* (ventral)	2.61 ±0.78[B]	4.09 ± 0.77[A]	4.21 ± 0.78[A]	<0.0001
b* (ventral)	0.67 ± 0.99[B]	1.79 ± 1.27[A]	1.95 ± 1.72[A]	0.0134
L* (dorsal)	52.39 ± 2.54[B]	61.17 ± 1.48[A]	62.03 ± 1.39[A]	0.0001
a* (dorsal)	3.22 ±1.31[B]	4.76 ± 1.61[A]	4.41 ± 1.43[A]	<0.0001
b* (dorsal)	0.82 ± 0.27[B]	1.43 ± 0.66[A]	1.24 ± 0.34[A]	0.0001
WHC	75.13 ± 2.82[A]	72.14 ± 1.32[B]	73.68 ± 2.86[B]	0.0038
CL	22.73 ± 1.99	23.86 ± 2.42	21.45 ± 2.89	0.3469
SF	14.26 ± 1.71[A]	13.42 ± 2.81[A]	11.59 ± 1.79[B]	0.0052
Total collagen (%)	0.216 ± 0.17[C]	0.335 ± 0.16[B]	0.446 ± 0.19[A]	0.0001
Soluble collagen (%)	0.069 ± 0.034	0.075 ± 0.040	0.093 ± 0.042	0.1723
Insoluble collagen (%)	0.198 ± 0.216[B]	0.309 ± 0.121[A]	0.316 ± 0.173[A]	0.0001
Sarcomere length (μm)	1.95 ± 0.05	1.95 ± 0.04	1.96 ± 0.05	0.1155

[ABC]Means followed by different letters (in the lines) differ from each other by the Tukey test ($P < 0.05$). Lightness (L*), redness (a*) and yellowness (b*) of the ventral and dorsal surfaces, Water-holding capacity (WHC), cooking loss (CL) and shear force (SF).

were comparable to those of the unaffected samples. Therefore, as the occurrence of WS only marginally affected the quality traits of turkey meat, it seems reasonable to hypothesize a specie-specific physiological response towards the profound changes in muscle development resulting from genetic selection. These authors found no difference ($P > 0.05$) for Lightness (L*), redness (a*), yellowness (b*), CL, and SF, the same did not happen in this study, where there was no difference only for CL ($P > 0.05$) of all the quality characteristics of the evaluated to breast fillets of turkey breeder hens.

Petracci et al. (2013), found that there were no differences in the L* values of broiler meat with different degrees of WS, but moderate and severe samples showed a significant increase in a* and b*. In the present study, L*, a*, and b* were higher in samples with myopathies, both DPM and WS in ventral and dorsal surfaces of turkey breeder hens' breast fillets. Petracci et al. (2013), still reported that the magnitude of WS found in their study, demonstrated that this abnormality is becoming an important quality issue for the poultry industry. Fillets showing severe WS may be downgraded in commercial plants and not marketed for fresh retailing. This could cause economic damage to the poultry industry.

No differences ($P > 0.05$) in CL were observed for all treatments. Similarly, Carvalho et al. (2021), reported that the percentage of CL did not differ significantly between turkey breast meat affected by NORM and SEV degrees of WS and Cavalcanti et al. (2021), also found no significant difference for this variable studying DPM in turkeys. Tijare et al. (2016), in study of birds processed at 6 wk of age, showed similar results to those reported no difference ($P > 0.05$) between breast broilers fillets with SEV WS and those with NORM WS.

Contrarily, both WHC and SF ($P < 0.05$) of the turkey breeder hens' breast fillets were affected by the DPM and WS. Higher WHC values for meats without myopathies than for both degrees of severity were observed (score 0 / NORM > score 2 / MOD = score 3 / SEV), being such difference significant for both DPM ($P < 0.0041$) and WS ($P < 0.0038$). This change in WHC in turkey breeder hens' breast fillets is not beneficial in the processing industry and for the consumer market, as determines the loss of water during cooking, processing, transport and storage.

Considering the SF, only samples from the most severe degree of both myopathies, score 3 and SEV, were different, showing significantly lower values ($P < 0.0163$ and $P < 0.0052$ for DPM and WS, respectively). This shows a possible protein breakdown in the breast fillets affected by myopathies, since a greater WHC is an indication of intact and more soluble proteins, with high functionality and meat with greater protein functionality, tend to produce products with superior quality. Higher WHC values of meat can lead to greater muscle fiber turgor, which provides greater texture firmness, which is why meats without myopathies showed higher values for SF. The same behavior between the degrees of severity of myopathy for WHC and SF were observed by Carvalho et al. (2021), about WS and, for SF, in Cavalcanti et al. (2021), studying DPM.

Significant differences were observed for sarcomere length ($P > 0.05$) between fillets without myopathies and with DPM scores 2 and 3. Turkey breast fillets (*Pectoralis major*) from carcasses with *Pectoralis minor* muscles affected by DPM showed higher values for SL then score 0 (no DPM). A possible explanation for this result is that the actomyosin complexes of the myofibrils were dissociated, which resulted in an extension of sarcomere length. Although in the WS anomaly, no significant differences were observed for sarcomere length (**SL**). These results are in accordance to Carvalho et al. (2021), who reported similar results in the *Pectoralis major* muscles of turkeys.

Higher values of total collagen (%) were observed for the most severe category for both myopathies and for DPM, these higher values were in breast fillet from myopathy. Soluble collagen values (%) were significantly higher for DPM score 3 chicken breast fillets, however, with WS meat there was no difference ($P < 0.05$). Insoluble collagen (%) showed the same behavior for meat from DPM and WS, turkey breast meat with myopathies had higher values of Insoluble collagen (%) than meat absent from myopathy. The relative insolubility of collagen is due to its high tensile strength that forms intermolecular cross-bridges, influencing the tenderness of the meat. Interestingly, this association between genetics, weight, slaughter age, and the occurrence of muscular abnormalities demonstrated in turkeys. All these factors need to be studied and is the difference between the various studies currently.

In conclusion, the DPM and WS affect the color and cause a reduction in the water holding capacity of the breast fillets meat from turkey breeder hens. This may have a negative economic impact on the turkey's processing meat industry, because these are the main points evaluated by the consumer (color and texture), and meat juiciness determined by WHC contributes to eating quality as well as playing a role in texture. And this affects the quality of the muscle that belongs to the most valuable commercial cut. It is interesting to further research using these turkey meats affected by myopathies for processing in the industry, as an alternative for taking advantage and a way to reduce the impacts of losses, waste and economic damage.

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DISCLOSURES

The authors have no conflicts of interest to report.

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