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Muscle Alterations in Broiler Breast: A Mini Review

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Authors' contributions

This work was carried out in collaboration among all authors. Authors CDSL and JHS designed the study and wrote the first draft of the manuscript. Authors PMR and JHS contributed with discussions. Author CDSL managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Muscle alterations in broiler breast meat as Wooden Breast and White Striping have been investigated in different areas of expertise to find out the etiology or to decrease the incidence. Research involving additives supplementation and nutritional strategies showed a possible decrease in incidence, but it is important to note the consequences in broiler performance. Estimated heritability for White Striping defect was low to moderate, considering different ways to analyze the breast alterations scores and statistical methodologies. In Brazil, until 2019, carcass affected by Wooden Breast was condemned in the slaughterhouse, especially extreme severe degree. A recent decree published by governmental institution oriented to stop condemnation and oriented the destination of these meat, depending on severity degree of muscle alteration. This regulation is important to reduce the economic losses by poultry industries however, the occurrence of muscle defects will not stop. The measurement of the impact on processing and performance industries is still understood and need to be monitored by poultry companies. More studies about the impact of breast myopathies on economic losses considering this new scenario need to be available.

Keywords: Broiler; condemnation; white striping and wooden breast.

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1. INTRODUCTION

In the last decade, broiler production has observed changes in the appearance of breast muscle, such as White Striping (WS), Wooden breast (WB) and Spaghetti meat (SM). The fast-growing genetic line is pointed out as responsible for these changes or abnormalities in the pectoralis major muscle. The development of fast-growing genetic strains and increased breast yield are considered the main causes of these muscle defects [1,2]. Dalle-Zotte et al. [3] estimated about 5% the increase of breast yield. Muscle increase may trigger a series of changes in gene expression and consequently in metabolic pathways that induce inflammation and alterations in muscle structures [4].

These changes caused losses in the broiler meat processing industry, estimated on over 200 million dollar per year [2] and mobilized a range of researchers from different areas to discover the etiology of these alterations. The impact of myodegenerative disorders was not only in the appearance, but in the physical chemical meat composition, and technological propriety as water hold capacity, cook losses and firmness [5,6].

The use of meat affected by WS, WB or SM may impair food production because of detrimental losses to the poultry meat retailing and processing industry due to the impaired water holding capacity and textural properties [7]. Mudalal et al. [6] evaluated raw and marinated meat affected by WB and WS, and found a decrease in water holding/binding abilities. But, recently, Madruga et al. [8] observed no significative difference in sausage produced with normal and wooden breast, showing that the use of these meat was not a problem for processing product. These divergence on meat quality impact of processed products allow for more research.

In some countries, in the slaughterhouses the WB and WS meat destination depends on supervision criteria, and in some cases could be discarded, although there is no infectious agent involved [1]. For a better comprehension in how meat affected by myopathies impact on processing products, why these alterations occur in breast muscle and if it is possible to reduce them by genetic selection or nutrition management many studies were conducted in the last ten years.

2. MYOPATHIES CHARACTERIZATION

The most common methods to analyze WB and WS are by visual or palpation of pectoralis major muscle considering differences in severity degrees. Kuttappan et al. [9] suggested four scale to classify for WS defects, consisting normal degree with no white striations; moderated, striations lower than 2 mm; severe, striations upper than 2 mm and extremely severe, striations cover surface muscle and fat deposition in cranial portion.

WB defect was described by the scale: normal with absence of hardness; mild focal hardness and pale color, and severe diffuse hardness in all breast muscle; exudate and petechiae presence [10]. Nowadays, an extremely severe degree of WB was found in muscles and consisting by completely hard muscle, exudate covering surface, and presence of hemorrhagic regions [2].

A novel muscle alteration called Spaghetti meat due to the disconnection of muscular fiber bundles, was identify in Italy. Baldi et al. [4] and Tasoneiro et al. [11] described this muscle alteration as a reduction in structural integrity and a stringy and soft consistency of ventral-cranial portion of breast, as a consequence of cohesion losses in muscular fiber bundles.

In the literature, it is possible to find a considerable number of papers describing the histological aspects of WS and WB alterations [4,10,12] and SM [4]. In general, WS and WB muscular alterations can be characterized by degenerative lesions, followed by a regenerative response to replace the damage tissue by fibrosis or lipolysis. There is also an increase in the diameter of muscle fibers and a reduction in the degradation rate of proteins, with low capillarization, and consequently low oxygen supply [13]. The hardness aspect of raw WB was an increased amount of collagen, while SM breast had lower collagen cross-linking and could explain the fiber bundles separation in the muscle tissue [14].

These degenerative lesions or necrosis, fibrosis and lipidosis increase according to the severity of the WS and WB alterations, and may start to occur in broiler about 2-3 weeks old [15], even though there is no macroscopically aspect. At 46 day of age, Radelli et al. [16] detected fiber degeneration, at histology level, in almost all animals in the trial. SM muscles affect connective

tissue, characterized by decrease in fiber uniformity and a progressive rarefaction of the endo- and peri-mysial connective tissue leading to the formation of large intracellular spaces [4,11]. Baldi et al. [14] showed that WB, WS e SM impact in different intensity the *pectoralis major* muscle, affecting the superficial section more than deep section.

Genomic studies aimed to elucidated and understand how gene expression was related to these myodegenerations [17,18,19]. Interesting finds were discovered by these studies and confirm differentially expressed genes related to, for example, oxidative stress, intracellular calcium, hypoxia, and inflammation. Also, these authors observed differences in muscle development, polysaccharide metabolic processes, glucose metabolism, proteoglycans synthesis corroborating with the results of high collagen and fat presence in WB/WS muscles [10,12,20,21]. Zambonelli et al. [17] described a hypothetical cascade of muscle alterations progression, started by genetic selection for high growth rate and breast yield. These factors altered significative metabolic pathways acting simultaneously to promote the fiber-type switching.

There is no scientific evidence of infectious agent presence such as bacteria or parasites in broiler muscles affected [1]. So, it is a consensus that is not a public health problem. Due to the changes in the affected muscle appearance and differences in the physical chemical attributes, it is uncertain the destination of these altered muscles by the poultry meat industry.

It is a consensus that these muscle breast defects impact on meat quality parameters because the marble appearance [13,20] and the presence of bloody and exudate in the WB meat lead a rejection by the consumer. Losses in water hold capacity, emulsifying, cooking losses differences [11], may reduce the quality of processed products, or raw and marinated meat [6]. But Madruga et al. [8] observed no significative influence of WB extremely severe degree in quality parameters of sausage production. The use of this raw material for processing may lead to a reduction in industrial efficiency and these negative impact in the economic profitability of the process industries need to be more investigate.

For the textural properties of cooked fillets, there were significant differences in hardness and chewiness between normal and WB. The consumer acceptance declines for the white-striped meat because the marble appearance [13,20] and the presence of bloody and exudate in WB meat lead a rejection by the consumer [7,22].

3. NUTRITIONAL AND GENETICS RESEARCH

Studies in Poultry Nutrition tried to find additives or nutritional strategies to reduce myopathies incidence, with no negative impact in the bird performance and cuts yield at slaughter. Dietaries strategics as supplementation of vitamins E [22,10] and Selenium [16] aimed to reduce oxidative stress, but no significative reduction on myopathies incidence were observed.

Evaluations with the objective to deaccelerate growth curve as reduced Lysine levels [23] and energy and amino acid density [24,25,26] or nutritional strategies as feed restriction [24,25,26] showed an efficiency in a significative reduction in incidence of severe degrees [10,13,27,28], however, a decrease in body weight was observed too. So nutritional strategies may be evaluated with caution by the poultry producers and more nutrigenomics studies might be conducted to elucidate how these nutrients affect the gene expression and how these defects appear in the muscle.

In the literature, several researchers considered the fast-growing genetics lines and the high breast yield as the myopathies causes [10,13,27,28]. For this reason, genetic companies aimed to mitigate these problems by selection against the muscle affected by WB and WS in the pure breed line. Collect the phenotype information is not so simple because depends on subjective methodologies, as palpation and visual appearance of breast muscle, or high cost methodologies as magnetic resonance or ultrasound [1] in live birds. Heritability for WS estimated in two commercial pure breeds selected for high and moderate breast meat yields were moderate (0.34) to low (0.18), respectively [29]. Alnahhas et al. [30] found a high heritability (0.65) for WS in hybrids birds originated from two lines divergent selected for breast meat quality (pH ultimate). Divergent results may be due differences in genetic selection, estimation methods and data collection (categorical x continuous).

Even though greater body weight could be not the only cause responsible for pectoral muscle alteration. Environmental conditions, as house rearing technology, may influence the incidence of pectoral muscle defects, because better temperature and humidity control should contribute to increase body weight and decrease illness birds. An increase of SM defect in birds reared at Dark house aviary barn comparing with traditional system (tunnel ventilated model) was found in Brazilian poultry production [31].

Multifactorial trials are conducted to evaluate interactions among the possible causes. Livingston et al. [32] evaluated different periods of egg storage, time-limited feeding and two genetic lines, one selected for Body weight and another, strain selected for greater yielding breast meat, and concluded that birds from longer stored egg, subjected to *ad libitum* feed had greater WS scores despite their reduced BW. Considering genetic background, body weight of genetic line selected for Yield broilers was significantly correlated with WB ($r = 0.30$; $P < 0.01$), in agreement with Alnahhas et al. [27].

4. BRAZILIAN RULES

In Brazil, the incidence of breast muscle alterations was reported in many slaughter/processing industries in different country regions. At first moment, Brazilian Federal Inspection System classified as a condemnation cause in the slaughterhouse called as myopathies. Muscles affected by Wooden Breast alteration classified as a severe degree were condemned because of disgusting visual appearances (presence of hemorrhagic regions and expressive presence of exudate). In the same way, in United States WB breast were discarded from the processing line [33], causing economic losses in poultry industries.

In 2019, a new orientation of Ministry of Agriculture, Livestock and Supply (MAPA, Ministério da Agricultura, Pecuária e Abastecimento), changed the rules for the destination of meat affected by WB and WS. The document Circular Office No. 17/2019 [34], altered in Decree nº 10.468/2020 [27] advised to do not condemn muscle breast defects and oriented the correct destination of this meat in according to severity classification. In cases of mild and moderate WB, it is possible to remove the affected portion and use the unaffected part for fresh consumption and/or processed products; in severe degree is intended for inedible products. For the WS occurs the classification and segregation by the industry to allocate as a processed product or fresh meat consumption.

It is an important resolution for the modernization of Brazilian regulation of industrial and sanitary inspection of products animal origins and makes possible that meat affected by muscle defects could be correctly intended by processing industry instead of discarding them. But it is also important to considered that this new resolution will not reduce the incidence, nor will mitigate the impact on the processing and *in natura* sale of these kind of meat. Thus, despite the non-pointing of the changes by the Federal Inspection System, it is necessary that the industry maintains the monitoring of the incidence of these changes, to monitor the incidence by quality department and reports to the companies of genetics and nutrition.

5. CONCLUSION

The etiology of muscle changes is still unknown and genomics studies showed the complex genes alterations in important metabolic pathways [27]. Genetics breeding focus to bring the solution by selection against these traits as WB, WS and SM, however, difficult in measurement, uncertain genetic control, and the gap between selection in pure line and the hybrid commercial herd, the solution will not disappear immediately. Besides genetics and metabolism process studies to especially understanding of the onset in the breast muscle defects, it is important to continue the studies in nutrition and meat quality sectors. The measurement of the impact on processing and performance industries is still understood and need to be monitored by poultry companies. More studies about the impact of breast myopathies on economic losses considering this new scenario in Brazil need to be available.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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