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Roles of Environment, Nutrition, and Genetics in Woody Breast Condition in Chickens

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ABSTRACT

Woody breast (WB) condition is a muscle disease in broiler chickens that makes breast meat hard and rubbery, and it has a negative impact on the texture and appearance of fast-growing broiler chicken breast muscle. This condition is safe for consumers, but the meat generally goes under extra meat processing, such as making pet foods, because of lower consumer acceptance, which is an additional cost for the industry. The exact etiology of myopathy is unknown. Although there is no promising solution for the issue, several strategies, such as nutrition, have been introduced to reduce the WB rate. The present study reviewed the strategies that improved WB conditions, including genetics, nutritional, and environmental factors such as temperature and air quality.

Keywords: Broiler chicken, Environment, Genetic, Mitochondria, Nutrition, Woody breast

INTRODUCTION

Woody breast (WB) negatively impacts the texture and appearance of chicken breast meat. The fillets show noticeable stiffness and distinct histological composition (Sun et al., 2022). Although the meat has no health risks to humans, it significantly costs the poultry industry (Caldas-Cueva and Owens, 2020), as the meats are mostly used for byproducts that require further processing, and the final products are cheaper than the breast muscle.

Studies linked the problem to the disruption of ATP production (Wang et al., 2023) and mitochondria function (Shakeri et al., 2024). However, it has been indicated that more factors are related to the severity of WB, such as genetics, nutrition, and environment (Caldas-Cueva and Owens, 2020). Several approaches have been used to improve the WB, but so far, none of the strategies mentioned above have offered a completely promising solution. Therefore, the present review aimed to offer a list of strategies that reduced WB severity in broiler chickens.

ENVIRONMENT

Improving environmental factors such as the housing condition and environmental temperature can significantly impact the development of WB in chickens, potentially, they can be related to oxygen deprivation in the breast muscles, which is considered a key contributor to this muscle condition (Caldas-Cueva and Owens, 2020).

Temperature

Short/long-term high environmental (2-3h for short-term and 8-12h for long-term) temperatures worsen the severity of WB (Al-Abdullatif et al., 2024). High environmental temperature exacerbates muscle oxygen deprivation and contributes to WB development. Under heat stress, a chicken's body generates an excessive amount of reactive oxygen species (ROS) (Shakeri et al., 2020), leading to higher damage to muscles by increasing fibrous connective tissue that contributes to WB (Shakeri et al., 2023).

Furthermore, heat stress disrupts normal muscle growth by reducing the absorption of essential nutrients such as minerals and vitamins, contributing to the development of WB. Studies indicated that additives such as minerals (Cauble et al., 2020; Kuttappan et al., 2021) and vitamins (Kuttappan et al., 2021; Meyer and Bobeck, 2023) or a combination of both could improve WB condition by reducing oxidative stress in breast muscle tissues. A combination of vitamin E and selenium improves enzyme activity while reducing oxidative stress, leading to improved chicken performance under heat stress (Shakeri et al., 2020). The optimum environmental temperature for adult broiler chickens is between 18-22 °C (Shakeri et al., 2020). Therefore, to reduce the impacts of heat stress on WB, proper solutions should be considered during warm seasons to cope with the problem, such as reducing the number of birds per area, increasing housing ventilation, and supplementing diets with additives such as antioxidants and betaine.

Humidity

Optimum relative humidity (50–70% after brooding and 60–80% during brooding, RH) plays a major role in the health and productivity of broiler chickens. Excessive RH may compromise gut health and the immune system (Chigwada et al., 2022), leading to higher oxidative damage to tissues (Mishra and Jha, 2019). A combination of RH and heat creates a stressful condition that elevates the production of ROS, leading to potential damage to tissues and affecting their growth performance and meat quality, including WB (Oke et al., 2024).

Stocking Density

Higher stocking density increases heat stress incidents during the summer or in tropical areas, which can negatively impact broiler chickens' health and performance (Shakeri et al., 2015). High stocking density leads to higher oxidative damage to tissues (Shakerı et al., 2015) by altering immunity and gut health (Chigwada et al., 2022). Previous works indicated that reducing the number of birds per area could reduce oxidative stress in broiler chickens, resulting in a reduction in WB (Pekel et al., 2020; Son et al., 2022). The optimum space required for a bird is 0.1m^2 (v) (Pettit-Riley et., 2002).

Ventilation

Poor ventilation can lead to reduced oxygen levels in the chicken house, further contributing to hypoxia in the breast muscles. WB links to a lack of sufficient oxygen supply to the breast muscle (Shakeri et al., 2024), causing a condition known as hypoxia, which leads to oxidative stress and muscle damage. Considering proper ventilation systems for industrial buildings could improve the air quality of broiler chickens. Ventilation is essential to provide healthy environmental conditions. Unfortunately, failing to maintain adequate house temperatures will force broilers to consume excess feed to maintain body temperature rather than spend on growth performance. The feed used for maintenance cannot be used for growth, and this will have a detrimental effect on the feed conversion ratio and flock performance (Tabler, 2014).

Nutrition

This strategy is the cheapest and most practical method to cope with WB issues. Diet composition, including the different levels of protein, energy, and certain nutrients, can influence muscle development and the likelihood of WB.

Minerals

Minerals such as selenium reduce the incidence of WB in broiler chickens (Kuttappan et al., 2021). Trace minerals such as selenium are bio-available and reduce oxidative stress in tissues (Shakeri et al., 2020). A study showed that trace minerals had a 44% reduction in severe WB (Kuttappan et al., 2016) compared to other groups in their study. The reason behind the benefits might be related to the antioxidant properties of the minerals (Horváth and Babinszky, 2018). The addition of minerals to a diet has been shown to maintain the antioxidant defense and lead to healthy longevity (Tan et al., 2018). Antioxidants are essential in reducing ROS in tissues and protecting them against oxidative damage. Additionally, mitochondria-targeted antioxidants have great potential against damage by eliminating excessive ROS (Oyewole and BirchMachin, 2015).

Vitamins

Vitamins B complex, C, E, and D play a major role in healthy muscle function and blood circulation, which can be important for preventing muscle damage that contributes to WB. Among all vitamins, vitamin C seems to be the most effective one against WB (Meyer and Bobeck, 2023). Supplementing diets with vitamin C has been evaluated to significantly reduce WB (Cemin et al., 2018). Vitamin C is a potent antioxidant that can help regulate the production of ROS and reduce oxidative stress damage. It can also protect the cardiovascular system by improving mitochondrial function and maintaining antioxidant levels (Zheng et al., 2024).

Amino Acids

There is a strong link between imbalances in amino acid availability and the development of breast muscle, which is associated with increased oxidative stress (Trithavisup et al., 2024). Amino acid oxidation helps the body to release energy. However, a higher protein intake may increase the oxidation of amino acids, which can lead to oxidative stress if the antioxidant defense is disrupted. Reducing the overall level of amino acids, particularly by lowering the ratio of arginine to lysine, can help mitigate the occurrence of WB (Meyer and Bobeck, 2023) by potentially preventing the loss of muscle mass and function.

GENETICS MODIFICATIONS

Fast-growing breeds, such as Ross and Cobb, and heavier broiler chickens have a higher incidence of WB (Caldas-Cueva and Owens, 2020). There are several studies indicating that high breast meat yield broiler chickens showed a higher incidence of WB compared to not genetically modified birds (Mazzoni et al., 2015; Petracci et al., 2013). Studies also indicated that WB can be detected at early ages, as early as 3 weeks, suggesting the problem could be related to genetics (Che et al., 2022). The genetic modifications may have side effects such as altering mitochondrial function by affecting different proteins (Shoop et al., 2023), potentially leading to disruptions in energy production within the cell and leading to various alterations, including WB. Previous studies associated WB with mitochondria function and energy production (Shakeri et al., 2023; 2024).

CONCLUSION

Several factors, including environment and genetics, impact the severity of WB, while appropriate supplementation of vitamin C, minerals, or amino acids could improve the condition by removing ROS and improving mitochondria function. However, the additives alone cannot fully eliminate the problem. Therefore, the current review suggests that environmental and genetic factors potentially are better strategies to cope with the WB.

DECLARATIONS

Availability of data and materials

All provided data in the text is available upon reasonable request.

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Authors' contributions

Majid Shakeri contributed to the preparation of the manuscript. Majid Shakeri checked and approved the final version of the manuscript for publication in the present journal.

Competing interests

The author has declared that no competing interest exists.

Ethical considerations

The author has checked the ethical issues, including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy.

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