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Intensive genetic selection and meat quality concerns in the modern broiler industry

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Abstract. The genetic selection toward bigger broilers provoked the development of muscular myopathies and abnormalities. Since the affected meat is downgraded and often inadequate for further processing, economic losses to the broiler industry are inevitable. In addition, not only the nutritional value of the meat has been decreased, but also sensory properties and technological traits seem to concern consumers more. This can have a very negative attitude toward poultry meat as consumers connect these traits with poor animal welfare. To avoid these problems in the future, new studies must be focused on identifying markers in live birds for newly developed myopathies. Also, better strategies for determining genetic factors, nutritional and slaughter conditions, and hence meat quality, are a complex concept, and all factors together have an impact on parameters of meat quality.

1. Introduction

Of all animal products over the last three decades, the highest absolute and relative growth was made in the poultry meat industry. This not only demonstrates the significant role that poultry meat has as a low-priced protein source for a growing global population, but also the efficient production strategies. Between 1961 and 2019, world meat production rose from 9 to 132 million tonnes, and today poultry meat accounts for about 39% of global meat production. What makes poultry meat so popular among other types of meat is the fact that there are no religious taboos in the consumption of poultry meat, the carcasses are small-sized, broiler meat can be consumed as a whole bird and in parts, and there is no need for refrigeration in contrast to pork and beef meat. This also explains why poultry meat has, apart from egg consumption, become the main protein source for a growing population in many less-developed and threshold countries. Because of this rapid increase in the consumption and demand for poultry products, scientists along with producers have made an effort in developing new methods in the formulation of poultry diets, farming systems and techniques of genetic selection.

2. Factors affecting meat quality

The most significant concern of the modern broiler industry is how to produce high-quality meat in an economically and environmentally sustainable manner. The main goals for poultry productivity are to



achieve high meat yield, good meat quality and high feed conversion efficiency, and this is quite a challenge, particularly because altering one factor will affect the others as well.

Meat quality is determined by complex interactions between the animal's genotype and its environment (nutrition, rearing methods and slaughter conditions). The first level in improving meat quality is taking advantage of the diversity of breeds or strains to exploit valuable animal characteristics. The second level denotes within-breed genetic variability in order to improve meat quality through genetic selection. This intensive selection toward fast-growing and high-yielding broilers resulted in having modern broiler lines that reach processing by 6 weeks of age with a breast muscle that is almost 90% larger than the broilers produced in the 1950s [1]. This tremendous growth of *m. pectoralis major* has led to changes at the morphology and molecular levels that have a negative impact on meat quality [2, 3]. As the number of muscle fibres is determined at the time of hatching, continued selection for post-hatch muscle growth will only impact increasing muscle fibre sizes, not the number of fibres [4]. Increasing fibre size leads to poor vascularisation of muscle fibres, as the distance between capillary support and muscles is increased [3] with consequences of muscle hypoxia, difficulty in delivering essential nutrients and removing waste products of muscle metabolism, such as lactic acid, which necessarily accumulate in the muscles [5]. These alterations are thought to be notably responsible for the development of known myopathies and muscle defects, such as: deep pectoral myopathy, focal myopathy, white striping, pale, soft and exudative meat and wooden breast [5].

3. Intensive genetic selection and modern broilers concerns

Using genetic selection techniques for increasing body weight and growth rate of broilers that have bigger breast muscles and lowering feed conversion has led to noticeable changes from commercial broilers in the 1950s to the broilers in 1991 and 2001. From these studies, it is clear that the implementing genetic selection in the poultry industry has made 85 to 90% improvement in the birds, and created broilers as we see them today [6, 7]. Unfortunately, with intensive genetic selection that is developing at tremendous rates, modern broilers are more prone to health issues associated with fertility [8, 9], diseases [10, 11, 12] and consequently, with meat quality as well [13, 14, 15]. Recently, the biggest concern to the broiler industry is the occurrence of myopathies that are affecting not only the welfare of animals but also the nutritive value and consumer acceptability of products. Two myopathies, wooden breast and white striping, are found globally [16, 17, 18]. Even though these myopathies do not concern meat safety but, rather, meat quality, they cause huge economic loss for all producers in the modern poultry industry around the world. According to Tijare et al. [19], the occurrence of wooden breast in flocks was up to 96.1%. Economic loss to the US poultry industry with the incidence of severe wooden breast is estimated to be from \$US 200 million up to \$US1 billion per year [15, 20]. In order to reduce or even eradicate these myopathies, we must develop novel methods of selection and make changes to the environment.

4. Meat quality modification using genetic selection

Meat quality parameters are easy for researchers to measure, but defining specific factors that contribute to meat quality is quite a challenge. One of the underlying determining factors of meat quality is genetic input. Breeders are now well informed and educated, taking the role of creators of modern broiler lines, selecting desired performance traits (fast-growth, high-weight breast meat, efficient feed conversion, resistance to diseases, low incidence of myopathies, and others). Decisions regarding which meat quality traits to include in broiler breeding schemes are dependent on their level of heritability and genetic correlation with other economic traits. **The** heritability of several traits is well documented by Mir et al. [21], in relation to declining postmortem pH (0.35-0.49), lightness or meat colour (0.5-0.75) and drip loss (0.55-0.64). In recent years, problems with selection programs in broilers are more evident. The desire to control meat colour and pH is having a negative impact on meat quality traits, as those traits are being neglected through each generation of breeding. In genotypes selected for high growth and muscle yield, a slight variation towards higher ultimate pH (pH 5.9 vs. 5.8 on average) has been detected [22, 23, 24, 25], probably due to lower glycogen content in breast muscle. Also, the quality of meat has

been affected by significant positive and negative correlations between the cross-sectional area of muscle fibres and ultimate pH or glycolytic potential in broiler pectoral muscle [26]. This could explain why muscles with increased fibre sizes (and therefore ultimate pH) have lower values for meat lightness, drip and cooking loss, and toughness in broiler breast meat [24, 25, 26, 27].

Based on one study [28], the heritability of wooden breast in broilers is relatively low, and it is hypothesized that non-genetic factors contribute to alterations observed in meat with this myopathy [29]. Nowadays, several companies are searching for new markers that could be used in selection to improve meat quality [30].

5. Efforts to preserve genetic variability in the broiler industry

Even though technology, especially genomics, is evolving very fast, for most developing countries, these developments are still costly and out of reach. Major breeding companies will try to implement genomic knowledge to get lines of broilers that are resistant to many threatening diseases and that are in good condition. If they succeed, it will threaten to eradicate many local indigenous breeds. According to FAO [31], the regions with the most specialized poultry industry were also regions with the greatest proportion of their breeds categorized as at risk – Europe and the Caucasus, and North America (49% and 79% of poultry breeds respectively). Moreover, these regions also registered the highest number of breed extinctions.

Hence, genomic science must be applied in the conservation of local poultry populations as well, and to point out the importance of preservation of genetic variability among animals. New breeding schemes have improved the productivity of indigenous chickens using cross-breeding. With this strategy, it is possible to provide greater productivity, but it can have a negative effect on losing or diluting morphological features and instincts for broodiness in birds. Therefore, the balance between human requirements and aspirations with the rules of nature must be our priority.

6. Conclusion

The high absolute and relative growth rates in the poultry industry are a result of the success in breeding, which produced bird strains with excellent feed conversion and good health available. Over the last 10 years, with the development of different molecular studies, the interest of scientists in the field of genetic control of meat quality has not decreased. Many new challenges have appeared regarding a better perception of the origin of metabolic defects (related to the postmortem pH drop) or structural defects (white striping and wooden breast). Efficacy of selection depends on identifying quick and nondestructive methods which apply biological or genetic markers of poultry meat quality that will help in further genetic selection programs. Of course, the main goal is increasing favourable attributes of meat quality parameters in the selected lines and concurrently avoiding the incidence of meat quality defects. However, we must not forget that chickens produced for food are living beings, which have been suffering in silence for too long, surviving in unsuitably crowded conditions, and being overweight and unable to move. We have reached a point where meaningful reforms must be implemented. One of the solutions is moving back to breeding slower-growing birds, and there are a lot of possibilities that can be further investigated so that productivity and welfare come to balance again.

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