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Heritability and genetic correlation estimates for performance, meat quality and quantitative skeletal muscle fiber traits in broiler

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ABSTRACT

Broiler feed efficiency and meat quality are the primary factors considered by the poultry industry. This study was conducted to estimate heritability and genetic correlation coefficients for skeletal muscle fiber number, area and diameter and performance and meat quality traits of *Pectoralis major* in a single male broiler line. (Co) variance components were estimated by restricted maximum likelihood method, using the software MTDFREML. The numerator relationship matrix was composed by 77,474 individuals. Heritability coefficient estimates ranged from moderate to high for juvenile BW, breast weight, ultrasound record of pectoral muscle, lightness and thawing meat loss. Genetic correlation estimates for performance and skeletal muscle fiber traits indicated that selection for higher breast weight and juvenile BW could reduce muscle fiber number and increase muscle fiber diameter and area, which could prejudice the meat quality of this line. Selection for muscle fiber number and against muscle fiber diameter and area might improve meat water retention ability and tenderness in this broiler line, and selection programs could consider those traits as selection criteria, although this may be costly. We recommend the evaluation of the indirect selection caused by the use of the performance traits as selection criteria especially for juvenile BW and breast weight. Direct, intense selection for both traits might be unfavorable for most of the meat quality traits analyzed, which could lead to losses to both the chicken meat processing industry and consumers.

1. Introduction

The poultry industry searches for products that meet industrial and consumer demands. Selection programs of commercial broiler lines seek fast weight gain and conformation, favoring breast yield (Scheuermann et al., 2004). Differences in broiler weight and breast meat content are related to the number and size of muscle fibers, which are influenced by several environmental and genetic factors (Rehfeldt et al., 2000; Tesseraud et al., 2000; Christ and Brand-Saberi, 2002; Gonzales and Sartori, 2002). It is therefore necessary to estimate the genetic parameters of histological muscle traits in order to better understand the expression mechanisms of these variables.

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The development of skeletal muscle in poultry occurs in two distinct periods. In the embryonic stage, the hyperplasia of muscle fibers (increase in the number of muscle fibers) is established when a large number of precursor cells is determined to express muscle-specific genes (Christ and Brand-Saberi, 2002). Later, in the period post hatching, occurs hypertrophy of muscle fibers (increase in the diameter and area of muscle fibers) primarily through the addition of protein and nuclei originating from the proliferation and fusion of satellite cells (Moss, 1968).

Selection for higher growth rates in broilers has caused variation in quantitative properties of muscle tissue. This can be related to problems in broiler meat quality, which can affect functional characteristics of meat (Dransfield and Sosnicki, 1999; Velleman et al., 2002; Velleman and Nestor, 2003; Scheuermann et al., 2004; Gaya et al., 2011). Thus, estimation of genetic correlations among quantitative skeletal muscle fiber properties, meat quality attributes and other traits commonly used as selection criteria in animal breeding programs would help anticipate the influence of direct selection on other traits, or conversely, how previous selection has affected muscle fiber proprieties and meat quality. Since measuring these traits is a complex process and involves the slaughter of animals, studies of these parameters in poultry are rare in the literature.

The aim of the research was to estimate heritability and genetic correlation coefficients for performance, meat quality and quantitative skeletal muscle fiber traits of *Pectoralis major* in a male broiler line. Results could help characterize the association between these traits in the male line studied and the identification of selection criteria associated with differences in meat quality.

2. Material and methods

2.1. Data collection of performance and meat quality traits

Sibs from an elite flock that had undergone selection for development of a male line of a commercial poultry breeding program in Brazil were used, which was selected to emphasize performance and carcass traits. Pedigree chicks were wingbanded at hatching and housed and raised as recommended by the company guidelines for nutritional planning, management conditions and vaccination on a breeder unit. Data of meat quality and quantitative skeletal muscle fibers traits were collected from seven flocks between August 2006 and December 2007. Data previously collected from broilers of this male line were also incorporated into the dataset. The final dataset consisted of 624 sires and 5062 dams. On the breeder unit, an ultrasound (US) record of the average pectoral muscle depth in longitudinal and transversal directions and juvenile BW (JBW) were recorded at 38 d of age for the sib test flocks. From Aug. 2006 to Dec. 2007, each flock of sibs was transported at 44d of age to Pirassununga, São Paulo, Brazil, for meat quality and carcass measurements, and sample collection for the histological analysis, for a total of 7 slaughters. Animal identification and data were automatically recorded using portable terminals and bar code readers.

Ten hours prior to slaughter, feed was removed and broilers were held in transportation crates. Transportation of broilers to the processing plant took place at night and consisted of a 6 h journey. Upon reaching the processing plant, broilers were allowed to rest approximately 2 h before slaughter.

The processing plant was semi-industrial. Broilers were stunned by electric shock for 9 s at 40 V and 60 Hz for an average 45 mA per bird. Processing speed was carried out to allow adequate time to perform all measurements. Broilers were bled for 3 min. Prior to feather removal, broilers were immersed in water at 57 °C for 2 min. After evisceration, carcasses were chilled at 0–4 °C in water and ice, followed by storage at 0–2 °C for 24 h and deboning. Meat quality data from the sib test flock were all taken from the *Pectoralis major* muscle and collected as follows. Internal meat pH and temperature were measured by inserting the electrode approximately 5 mm into the cranial portion of the right side of the muscle, during 15 min (pHi), directly on carcass, and 24 h on deboned and skinless breast (pHu) after slaughter using a digital pH meter (Fernandez et al., 2002). At this time, small samples of the *Pectoralis major* muscle were also collected, placed in labeled tubes and immediately fixed in a 10% formalin buffer solution for 48 h followed by storage at 4 °C. After pHi measurement, carcasses were submitted to pre-chilling by immersion in cold water at 10 °C for 10 min followed by storage in a cold chamber (0–2 °C). Color parameters were measured 24 h after slaughter using a portable colorimeter and CIELab scale parameters (Comission International de l'Eclairage [CIE], 1976) for lightness (L*), redness (a*) and yellowness (b*). The measurements were recorded at three points on the muscle, on the ventral surface of the right side of the sample, and the mean of these three points was considered the determined value.

Water holding capacity was measured as drip loss (weight loss during chill storage), thawing and thawing-cooking losses. Initial breast weight (W1) was measured in *Pectoralis major* samples collected from the right side of the muscle 24 h after slaughter. These samples were then stored in a net placed in a plastic bag at 0–2 °C and reweighed after 24 h (W2). Other *Pectoralis major* samples were collected from the right side of the muscle at 24 h after slaughter and weighed to provide another initial breast weight (W3). Samples were then frozen at −18 °C, defrosted at 4 °C and weighed (W4). Next, samples were cooked in an electric oven (Luxo Classic 2.4, Lary) preheated to 170 °C until the internal temperature reached 72 °C. Temperature was measured by internal thermocouples, and samples were weighed after cooking (W5). Drip (DL), thawing (TL) and thawing-cooking (TCL) losses were calculated as follows: $DL=(W1-W2)/W1$ (Honikel, 1998); $TL=(W3-W4)/W3$ (Galobart and Moran, 2004); $TCL=(W4-W5)/W4$ (Bressan and Beraquet, 2004).

Shear force was determined using the same samples utilized to calculate thawing–cooking losses, which were also submitted to Warner Bratzler shear test after cooking and cooling. Four parallelepipeds measuring $20 \times 20 \times 10$ mm were removed from each breast sample, and sheared by the blade of a Warner Bratzler device.