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Growth, carcass, fiber type, and meat quality characteristics in Large White pigs with different live weights

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ABSTRACT

The aim of this study was to compare the growth, carcass, histochemical, and meat quality characteristics in Large White pig groups that were categorized by live weight (Heavy and Light) and type I fiber percentage (High and Low), a procedure which resulted in four groups (Heavy-High, Heavy-Low, Light-High, and Light-Low). As expected, the Heavy group showed heavier live weight (114 vs. 94.7 kg, $P<0.001$) and larger loin eye area (53.3 vs. 47.8 cm^2, $P<0.001$), as well as, higher total number (1,223,000 vs. 1,140,000, $P<0.05$) and greater mean value cross-sectional area (CSA; 4031 vs. 3798 μm^2 $P<0.05$) of muscle fibers than the Light group. However, there were no significant differences in start and finish days among the groups ($P>0.05$). Heavier pigs harboring a higher percentage of type I fibers (HH) exhibited a similar mean CSA (3894 vs. 4101 μm^2) and total number (1,249,000 vs. 1,198,000) of muscle fibers, even though these pigs had a greater CSA of type I fibers (3181 vs. 2719 μm^2, $P<0.05$) and a smaller CSA of type IIB fibers (4048 vs. 4457 μm^2, $P<0.05$) compared to heavier pigs harboring a lower percentage of fiber type I (HL). Both the HL and Light-Low groups exhibited a rapid decline of muscle pH at the early postmortem period (5.90 and 5.85 vs. 6.08, $P<0.05$), paler surfaces (43.07 and 43.55 vs. 40.73, $P<0.05$), and higher degrees of fluid loss by exudation (6.26 and 6.39 vs. 4.22%, $P<0.05$) compared to the HH group due to their muscle fiber type composition. Thus, the HH pigs showed better meat quality characteristics without significant differences in growth and carcass performance compared to the HL pigs. Therefore, selection for increased live weight at the same age and muscle fiber characteristics, especially the increased type I fiber CSA and proportion, is one of the relevant indicators to improve and control meat quality without reducing the growth and carcass performance.

1. Introduction

Genetic selection within the pig industry has resulted in improved growth rates and lean meat yields. Thus, pigs exhibiting higher growth rates and body weights are the consequence of a long term process of domestication (Rehfeldt et al., 2008). In fact, growth rate is an efficient indicator in pig selection, because a higher growth rate is associated with a lower maintenance requirement and, thus a saving in feed costs (Webb and Casey, 2010). However, selection for increased growth rate and lean meat yield have resulted in concomitant changes in skeletal muscle characteristics including the muscle fiber which is the major constituents of skeletal muscle (Brocks

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et al., 1998; Picard et al., 2006; Rehfeldt et al., 2008; Ruusunen and Puolanne, 2004). Pigs with homozygous and heterozygous for the halothane gene exhibited generally higher carcass and lean meat yields (Rosenvold and Andersen, 2003). However, carriers of this gene are highly susceptible to stress (Larzul et al., 1997a; Rosenvold and Andersen, 2003), and muscles from carriers of the halothane gene showed different characteristics of the muscle fiber compared to muscles from non-carriers of the halothane gene (Rosenvold and Andersen, 2003). These changes in the muscle fiber characteristics, including the number and area of fibers and the fiber type composition, have been reported to negatively impact the technological and sensory qualities of meat (Choi and Kim, 2009; Rehfeldt et al., 2008).

It is accepted that both the number (hyperplasia) and size (hypertrophy) of muscle fibers are positively correlated with the growth rate and ultimate muscle mass (Rehfeldt et al., 2008; Ryu et al., 2004). Pigs with heavier body weights exhibit a greater muscle fiber cross-sectional area (CSA) and/or a greater number of muscle fibers than pigs with lighter body weights at the same age (Rehfeldt et al., 2008). Increase in muscle fiber size, especially muscle type IIB fiber, seems to reduce the capacity of the fibers to adapt to activity-induced demands which in turn may be associated with adverse effects on stress susceptibility and meat quality (Barbut et al., 2008; Choi et al., 2012; Fiedler et al., 1999; Karlsson et al., 1999; Rehfeldt et al., 2008; Webb and Casey, 2010). In the skeletal muscle of the domestic pig, the growth rate of type IIB fibers, also known as fast-twitch glycolytic fibers, is about two times faster than that of type I and IIA fibers during the growth period. Therefore, type IIB fibers are significantly larger than type I and IIA fibers at the same age (Ruusunen and Puolanne, 2004). Type IIB fibers mainly carry out glycolysis and their metabolism contributes to the rapid metabolism of glycogen in the early postmortem period (Choi and Kim, 2009; Choi et al., 2010; Pette and Staron, 2001; Schiaffino and Reggiani, 1996). Also, muscles harboring a higher percentage of type IIB fibers tend to produce a higher amount of lactate and more rapid pH decline at the early postmortem period, resulting in a generally poorer meat quality than muscles harboring a higher percentage of type I fibers (Choi et al., 2007; 2010). Meat animals selected for their muscle growth capacity produce muscles with a higher percentage of larger type IIB fibers in pigs (Ruusunen and Puolanne, 2004) and cattle (Cassar-Malek et al., 2003). Moreover, pigs with a higher percentage of larger type IIB fibers are associated with the incidence rate of pale, soft, and exudative meat (Webb and Casey, 2010; Barbut et al., 2008).

The Large White pig, a recent domestic breed, has better growth potential compared to other traditional pig breeds (Rehfeldt et al., 2008; Renaudeau and Mourot, 2007; Ruusunen et al., 2012; Weiler et al., 1998). However, the *longissimus dorsi* muscle of Large White pigs exhibit a higher percentage of type IIB fibers and a greater glycolytic potential than that of Berkshire pigs (Ryu et al., 2008), and produces lower marbled meat with poor technological and eating quality compared to Berkshire and Duroc pigs (Lee et al., 2012; Ryu et al., 2008). From a selection point of view, more information on the effects of growth performance and muscle fiber characteristics are needed in order to improve and control meat quality without diminishing the advantages in this breed. Therefore, the aim of this study was to compare the growth and carcass performance, histochemical, and meat quality characteristics in Large White pig groups that were categorized by live weight at slaughter and fiber type I percentage in the *longissimus dorsi* muscle.

2. Materials and methods

2.1. Animals and muscle samples

A total of 161 Large White pigs (81 gilts and 80 castrated pigs) with an average initial body weight of 34.5 ± 6.7 kg (initial age 86.0 ± 4.2 days), heterozygous for the halothane gene and clinically healthy, were used in this study. All pigs were tested to assure the halothane genotype according to Fujii et al. (1991). All pigs were weighed at the beginning and end of the experiment, and the average daily gain was calculated in this period. All treatments and experimental procedures were approved by the Ministry of Food, Agriculture, Forestry, and Fisheries in Korea. Pigs were reared on a commercial farm in separate pens (10–11 pigs per pen with 0.8 m^2 space per pig), and fed the same commercial diet in accordance with the National Research Council (1998). All pigs were transported to a commercial abattoir under the same handling conditions at a similar age (175.5 ± 4.1 days old; 102.9 ± 11.3 kg) in 4 batches (40, 40, 40, and 41 pigs per batch) during the winter period, using standard procedures under the supervision of the Korean grading service for animal products.

The slaughter plant used electrical stunning, and the pigs were exsanguinated and then placed in a dehairer at 65 °C for 5 min. Any remaining hair was removed with a flame and knife after exiting the dehairer. After evisceration, the carcasses were weighed and the carcass percentage calculated. The loin eye area was also measured at the level of the last rib. Back-fat thickness was measured at the 11th and last thoracic vertebra, and the mean of these two measurements was used as the back-fat thickness value.

At 45 min postmortem, muscle samples were taken from the *longissimus dorsi* muscles at the 7 and 8th thoracic vertebra of the carcass for the analysis of muscle pH ($pH_{45\ min}$) and lightness (L^*). At the same time, muscle samples were cut into $0.5 \times 0.5 \times 1.0\ cm^3$ pieces, then immediately frozen in isopentane using liquid nitrogen, and stored at −80 °C for the subsequent analysis, including muscle fiber characteristics and *R*-value. After 24 h in a 4 °C cold room, the pork loins (the 9–13th thoracic vertebra) were taken for meat quality measurement, then immediately frozen and stored at −80 °C for protein solubility measurement.

2.2. Histochemical analysis

Using a cryostat (CM1850, Leica, Germany) at −25 °C, serial transverse muscle sections (10 μm) were obtained