

## Carcass Performance, Muscle Fiber, Meat Quality, and Sensory Quality Characteristics of Crossbred Pigs with Different Live Weights

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### Abstract

In order to attain heavier live weight without impairing pork or sensory quality characteristics, carcass performance, muscle fiber, pork quality, and sensory quality characteristics were compared among the heavy weight (HW, average live weight of 130.5 kg), medium weight (MW, average weight of 111.1 kg), and light weight (LW, average weight of 96.3 kg) pigs at time of slaughter. The loin eye area was 1.47 times greater in the HW group compared to the LW group (64.0 and 43.5 cm<sup>2</sup>,  $p < 0.001$ ), while carcass percent was similar between the HW and MW groups ( $p > 0.05$ ). This greater performance by the HW group compared to the LW group can be explained by a greater total number (1,436 vs. 1,188,  $\times 10^3$ ,  $p < 0.001$ ) and larger area (4,452 vs. 3,716  $\mu\text{m}^2$ ,  $p < 0.001$ ) of muscle fibers. No significant differences were observed in muscle pH<sub>45 min</sub>, lightness, drip loss, and shear force among the groups ( $p > 0.05$ ), and higher live weights did not influence sensory quality attributes, including tenderness, juiciness, and flavor. Therefore, these findings indicate that increased live weights in this study did not influence the technological and sensory quality characteristics. Moreover, muscles with a higher number of medium or large size fibers tend to exhibit good carcass performance without impairing meat and sensory quality characteristics.

**Keywords:** live weight, carcass performance, muscle fiber, meat quality, sensory quality

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### Introduction

Live weight at slaughter is one of the most important economic factors in pig production (Correa *et al.*, 2006; Kim *et al.*, 2005). In the last few decades, the pork industry has attempted to improve market and carcass weights through genetic selection, improved feeding technology, and more efficient animal production systems (Correa *et al.*, 2006; Kim *et al.*, 2005; Rehfeldt *et al.*, 2008; Serrano *et al.*, 2008). This increased market weight has the benefit of reducing the direct and/or indirect costs to pork producers, slaughterers, and processors by increasing carcass weight and lean meat proportion and by reducing processing loss (Correa *et al.*, 2006; Peloso *et al.*, 2010; Serrano *et al.*, 2008).

Market weights are significantly different between countries and pig breeds. In Italy, pigs are traditionally slaughtered at a heavy weight (between 150 and 160 kg), and live

and carcass weights of Iberian pigs average 160 to 180 kg and 134 to 159 kg, respectively (Galian *et al.*, 2009; Serrano *et al.*, 2008). However, these higher live weights at slaughter tend to require longer rearing periods (more than 240 d) and extra economic input (Galian *et al.*, 2009). Alternatively, Yorkshire, Duroc, and Landrace are the traditional pig breeds in pork production in the USA and Korea, and these breeds make up 85 percent of all domestic pigs (United States of Department of Agriculture; USDA, 2016). Market weight in the USA is approximately 118 to 122 kg, and commercial pigs require approximately 180 d to achieve this weight (USDA, 2016). In Korea, the average live weight at slaughter is less (approximately 100 to 110 kg), even though the commercial breeds and age at slaughter are similar to those in the USA (Kim *et al.*, 2005; USDA, 2016). Hence, in the pork industry in Korea, pressure exists to increase market weight and ultimately muscle mass to decrease production costs and be more competitive in both domestic and international markets.

However, increased muscle mass obtained through intense genetic selection and feeding regimes have resulted in concomitant changes in the characteristics of muscle fibers, which are the major components of skeletal mus-

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cle (Choi *et al.*, 2013a; Choi *et al.*, 2014; Picard *et al.*, 2006; Rehfeldt *et al.*, 2008; Shin *et al.*, 2015). Generally, animals raised for meat production, such as quail, pigs, and cattle, weigh more and have muscles with a higher percentage of the larger type IIB fibers (fast-twitch and glycolytic) (Choi and Kim, 2009; Choi *et al.*, 2013b; Remignon *et al.*, 1995; Rehfeldt *et al.*, 2000). Extensive increases in muscle fiber area and the proportion of type IIB fibers in the muscle tend to reduce the capacity of the fiber to adapt to activity-induced demands, which in turn have detrimental effects on stress susceptibility, pork quality, and sensory quality characteristics (Barbut *et al.*, 2008; Choi *et al.*, 2013a; Rehfeldt *et al.*, 2008). For example, heavy weight pigs with a higher proportion of type IIB have a higher concentration of lactate and subsequent rapid pH decline in the early postmortem period due to their higher glycolytic capacity (Choi *et al.*, 2007, 2013a), and these factors are associated with a higher incidence rate of pale, soft, and exudative (PSE) pork (Barbut *et al.*, 2008; Ryu and Kim, 2005). While there are many studies investigating the effects of increased live weight at slaughter on growth efficiency, carcass performance, and meat quality characteristics, there are few on muscle fiber and organoleptic characteristics of different market weights of pigs (Correa *et al.*, 2006; Galian *et al.*, 2009; Kim *et al.*, 2005). Therefore, the objective of this study was to compare the carcass, muscle fiber, meat quality, and sensory quality characteristics among the heavy weight (HW, average live weight of 130.5 kg), medium weight (MW, average weight of 111.1 kg), and light weight (LW, average weight of 96.3 kg) groups to identify heavier market weights that do not result in deterioration of meat and sensory quality characteristics.

## Materials and Methods

### Animals and muscle samples

A total of 86 crossbred pigs (Landrace × Yorkshire × Duroc; 40 gilts and 46 castrated males) were used in the analyses having an average initial age and body weight of 86.0±4.5 d and 37.5±7.9 kg, respectively. All pigs were then transferred to the finishing barns. All pigs were weighed at the beginning and end of the experiment. The environmental conditions to which the pigs were exposed were the same both before and after slaughter. Pigs were reared on a commercial farm in separate pens (10-11 pigs per pen with 0.8 m<sup>2</sup> space per pig) and fed the same commercial diet in accordance with the National Research Council nutrient requirements (1998). All pigs were trans-

ported to a commercial abattoir under the same handling conditions at a similar age and weight (180.3±5.8 d of age and 106.4±13.4 kg, respectively) and were slaughtered during the winter under the supervision of the Korean grading service for animal products. Transportation and slaughter occurred in 3 lots (30, 30, and 26 pigs per lot) under the same conditions for each lot on the same day.

The slaughterhouse used electrical stunning, and all animals were exsanguinated and then placed in a dehairer at 65°C for 5 min. The remaining hair was removed with a flame and knife after exiting the dehairer. After evisceration, the carcasses were weighed, and the percent carcass weight was calculated as the proportion of live weight to the carcass weight × 100. Loin eye area was measured at the level of the last rib. Backfat thickness was measured at the 11th and last thoracic vertebrae, and the mean of these two measurements was calculated.

At 45 min postmortem, muscle samples were taken from the *longissimus dorsi* muscles at the 7th and 8th thoracic vertebrae to determine muscle pH (pH<sub>45 min</sub>). At the same time, muscle samples were cut into 0.5 × 0.5 × 1.0 cm<sup>3</sup> pieces, immediately frozen in liquid nitrogen, and then stored at -80°C for the analysis of muscle fiber characteristics. After 24 h postmortem in a 4°C cold room, pork loins were removed for meat quality measurements, and samples of the loins were frozen and stored at -20°C for analysis of the sensory characteristics of the cooked pork.

### Histochemical analysis

Serial transverse skeletal muscle sections (10 µm) were cut in a cryostat (CM1860, Leica, Germany) at -25°C and mounted onto glass slides. Myosin ATPase activity of the samples was detected following both acidic (pH 4.6) and alkaline (pH 10.7) pre-incubation (Lind and Kernell, 1991). Muscle fibers were classified as type I, IIA, or IIB using the nomenclature system of Brooke and Kaiser (1970). Stained muscle sections from each sample were examined via image analysis (Image Pro-Plus, Media Cybernetics, USA). Approximately 600 fibers were measured per sample. The average area of the muscle fibers was calculated as the total muscle area divided by the total number of fibers. The area of type I, IIA, and IIB fibers was determined, and the percent area of each fiber type was calculated as the proportion of the total cross-sectional area of each fiber type divided by the total area of the fibers × 100. The percent number of each fiber type was calculated as the proportion of the total number of each fiber type divided by the total number of fibers ×

100. The total number of fibers was determined by multiplying muscle fiber density by the loin eye area.

### Meat quality characteristics

To estimate the postmortem glycolytic rate, muscle pH at 45 min ( $\text{pH}_{45 \text{ min}}$ ) and 24 h ( $\text{pH}_{24 \text{ h}}$ ) postmortem was measured by directly inserting a spear-type portable pH meter (IQ-150 pH meter and PH77-SS probe, IQ Scientific Instruments Inc., USA) into the carcasses at the 8th and 9th thoracic vertebrae.

At 24 h postmortem, meat color was measured with a Minolta Chroma Meter (CR-400, Minolta Camera Co., Japan) after exposing its surface to the air for 30 min at 4°C. Results were expressed as Commission Internationale de l'Eclairage (1978) lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) values. The average of triplicate measurements was used. Regarding water holding capacity (WHC), drip loss, filter-paper fluid uptake (FFU), and cooking loss were measured. To determine drip loss, samples of approximately 80 g were trimmed and weighed. Each sample was then placed in 25 cm<sup>2</sup> of square netting and suspended in an inflated plastic bag for 48 h at 4°C (ensuring that the sample did not make contact with the bag), after which time it was re-weighed (Honikel, 1998). Drip loss was calculated as the percent weight change (Honikel, 1998). For FFU and cooking loss measurements, pork loin samples were cut into 2 cm thick chops. To measure FFU (Kauffman *et al.*, 1986), filter paper (Whatman® qualitative filter paper, Grade 2, 42.5 mm diameter) was pre-weighed, placed on the surface of a chop for less than 2 s to absorb fluids, and then weighed again. FFU was expressed as mg of exudates absorbed by the filter paper. The samples were then put in thin-walled polyethylene bags and placed in a continuously boiling water bath (80°C) until the internal temperature (measured using a thermometer with a handled probe; TES-1300, TES Electrical Electronic Corp., Taiwan) reached 71°C. Pork samples were then cooled in ice water for 15 min. The cooled samples were taken from the polyethylene bag, blotted dry, and weighed. Cooking loss was calculated as the difference between pre- and post-cooking weights (Honikel, 1998). Preparation of cooked meat samples for Warner-Bratzler shear force (WBS) was the same as that for cooking loss, and WBS was performed with six to ten cores (1.27 cm diameters) removed from the steak parallel to the longitudinal orientation of the muscle fibers. WBS was determined using an Instron Universal Testing Machine (Model 1011, Instron Corp., USA) equipped with a Warner-Bratzler shearing device. Subjective measures for

color (1 to 6, pale pinkish-gray to dark purplish-red) and marbling (1 to 10, 1% to 10% intramuscular fat) were evaluated according to National Pork Producers Council (NPPC, 2000).

### Sensory evaluation

Each of the 86 pork samples was evaluated twice, and 18 sessions of 10 samples tested per session were conducted. A sensory panel consisting of 12 pork-consuming individuals (20 to 40 years of age, 6 females and 6 males) was employed to evaluate the sensory attributes of the cooked pork. All training and testing were conducted at the Kyungpook National University. Before sensory evaluation, all panelists were trained for a minimum of 6 mon (3 times per wk) and up to 1 h in each training session. Panelist training was performed according to the American Meat Science Association guidelines (AMSA, 1995) and previously published procedures (Meilgaard *et al.*, 1991).

Samples were thawed overnight at 4°C and then cooked in a humid heat oven (MCS312CF4, Electrolux, Sweden) set to 180°C until reaching an internal temperature of 71°C, as measured by a TES-1300 thermometer (TES Electrical Electronic Co., Taiwan). Samples were then immediately sliced into 1.3 × 1.3 × 1.3 cm pieces, which were subsequently randomly selected to minimize bias. Samples were placed in 1-ounce lidded glass jar labeled with random three-digit codes and held in a water bath (54°C) until presented to the panelists. The samples were presented simultaneously to the judges in a compartmented plate. There was an interval of approximately 5 min between the evaluations of consecutive samples. During sensory evaluation, panelists were positioned in private booths under incandescent light, and served distilled water (at room temperature) and salt-free crackers before the first sample and between samples to cleanse their mouths.

Cooked samples were evaluated for softness (the force required to compress the meat between the molar teeth; 1=very hard, 9=very soft), initial tenderness (the force required to chew 3 times after initial compression; 1=very tough, 9=very tender), chewiness (the energy required at the 9th chew to swallow at a constant rate; 1=very chewy, 9=very tender), rate of breakdown (the number of chews required for the sample to disintegrate during the mastication process in preparation for swallowing; 1=very slow, 9=very fast), mouth coating (the amount of oil/fat left in the mouth surface; 1=none, 9=very high), amount of perceptible residue (the amount of connective tissue remaining upon complete disintegration of the sample; 1=abun-

dant, 9=none), juiciness (the amount of moisture released after 5 chews; 1=not juicy, 9=extremely juicy), flavor intensity (the intensity of pork flavor after 8 chews; 1=no pork flavor, 9=full pork flavor), and off-flavor intensity (the intensity of any flavor or aftertaste perceived as inappropriate to cooked pork; 1=very strong, 9=very weak) (AMSA, 1995; Meilgaard *et al.*, 1991).

### Statistical analysis

Cluster analysis was conducted using the FASTCLUS procedure in SAS (2009) to classify the pigs into groups of live weight, resulting in 3 clusters (Groups Light, Medium, and Heavy). After classification, the general linear model (GLM) procedure was applied to assess the association between groups and traits. No significant differences were observed for any variable between genders or lots. Significance was set at 5%. The results for the groups are presented as least squares means with standard errors.

## Results

### Carcass characteristics

Carcass characteristics for each live weight group are presented in Table 1. There was no significant difference in the age at slaughter among the groups. Live weight ( $p<0.001$ ) and average daily gain ( $p<0.001$ , data not shown) were approximately 1.4 times heavier in the HW group compared to the LW group. Carcass weight was also greater in the HW group compared to the MW and LW groups (95.5, 82.0, and 70.6 kg, respectively;  $p<0.001$ ), even though no significant difference was observed in the proportion of carcass weight relative to live weight. Moreover, the HW group had greater loin eye area than both the MW and LW groups (64.0, 51.2, and 43.5 cm<sup>2</sup>, respectively;  $p<0.001$ ) as well as backfat thickness (22.8, 16.4, and 13.7 mm, respectively;  $p<0.001$ ).

### Muscle fiber characteristics

There were marked differences in muscle fiber area among the groups (Table 2). The HW group exhibited a greater mean fiber area compared to the MW and LW groups (4,452, 4,008, and 3,716  $\mu\text{m}^2$ , respectively;  $p<0.001$ ), but there was no significant difference in type I fiber area among these groups. Type IIA fibers in the HW group were larger compared to the MW and LW groups (2,999, 2,435, and 2,322  $\mu\text{m}^2$ , respectively;  $p<0.01$ ) as were type IIB fibers (4,827, 4,209, and 4,077  $\mu\text{m}^2$ , respectively;  $p<0.01$ ). However, no significant difference was observed in total fiber number between the HW and MW groups ( $1,436\times 10^3$  and  $1,316\times 10^3$ , respectively), although the HW groups showed a significantly higher total number compared to the LW group ( $1,188\times 10^3$ ,  $p<0.001$ ). There were no significant differences in the area percentage of muscle fiber types among the groups. Similar to area percentage of fiber types, the HW group had a similar number percentage of fiber types compared to the MW and LW groups ( $p>0.05$ ).

### Meat quality and sensory characteristics

The influence of live weight on meat quality characteristics is shown in Table 3. Muscle pH<sub>45 min</sub> was not significant among the groups, whereas ultimate pH (pH<sub>24 h</sub>) was significantly higher in the LW and MW groups compared to the HW group (5.58, 5.60, and 5.46, respectively;  $p<0.05$ ). There were no significant differences in lightness and yellowness, but the HW group exhibited a lower redness value than the LW group (4.69 and 7.24, respectively;  $p<0.001$ ). Regarding WHC, drip loss and FFU were similar among the groups ( $p>0.05$ ). However, samples from the HW group experienced significantly greater cooking loss compared to samples from the MW or LW groups (22.1, 20.5, and 20.5%, respectively;  $p<0.05$ ). No significant difference in WBS as an indicator of tenderness was observed among the groups. Moreover, there were no sig-

**Table 1. Live weight and carcass characteristics in groups defined by the live weight**

	Live weight			Level of significance
	Light (N=44)	Medium (N=26)	Heavy (N=16)	
Age at slaughter (d)	179.3 (0.88) <sup>1</sup>	181.3 (1.14)	181.1 (1.56)	NS
Live weight at slaughter (kg)	96.3 <sup>c</sup> (0.08)	111.1 <sup>b</sup> (1.07)	130.5 <sup>a</sup> (1.45)	***
Carcass weight (kg)	70.6 <sup>c</sup> (0.90)	82.0 <sup>b</sup> (1.17)	95.5 <sup>a</sup> (1.59)	***
Carcass percentage (%)	73.4 (0.56)	74.4 (0.74)	72.4 (0.90)	NS
Loin eye area (cm <sup>2</sup> )	43.5 <sup>c</sup> (1.31)	51.2 <sup>b</sup> (1.64)	64.0 <sup>a</sup> (2.23)	***
Backfat thickness (mm)	13.7 <sup>c</sup> (0.79)	16.4 <sup>b</sup> (1.04)	22.8 <sup>a</sup> (1.42)	***

<sup>1</sup>Standard error of least square means.

Levels of significance: NS, not significant; \*\*\* $p<0.001$ .

Values with different lowercase superscripts within a row refer to significant differences between those groups ( $p<0.05$ ).

**Table 2. Muscle fiber characteristics of the porcine *longissimus dorsi* muscle in groups defined by the live weight**

	Live weight			Level of significance
	Light	Medium	Heavy	
Muscle fiber area ( $\mu\text{m}^2$ )				
Mean	3,716 <sup>b</sup> (91.4) <sup>1</sup>	4,008 <sup>b</sup> (126)	4,452 <sup>a</sup> (156)	***
Type I fiber	2,990 (120)	3,112 (158)	2,979 (203)	NS
Type IIA fiber	2,322 <sup>b</sup> (104)	2,435 <sup>b</sup> (137)	2,999 <sup>a</sup> (178)	**
Type IIB fiber	4,077 <sup>b</sup> (112)	4,209 <sup>b</sup> (141)	4,827 <sup>a</sup> (191)	**
Total Fiber number ( $\times 1000$ )	1,188 <sup>b</sup> (39.4)	1,316 <sup>a</sup> (51.0)	1,436 <sup>a</sup> (72.2)	***
Area percentage of fiber type (%)				
Type I fiber	6.19 (0.44)	6.13 (0.58)	6.54 (0.75)	NS
Type IIA fiber	7.08 (0.47)	6.66 (0.61)	7.19 (0.80)	NS
Type IIB fiber	86.7 (0.62)	87.2 (0.80)	86.3 (1.05)	NS
Number percentage of fiber type (%)				
Type I fiber	7.83 (0.57)	7.78 (0.74)	9.71 (0.96)	NS
Type IIA fiber	11.5 (0.76)	11.0 (1.00)	10.7 (1.29)	NS
Type IIB fiber	80.7 (0.80)	81.2 (1.05)	79.6 (1.37)	NS

<sup>1</sup>Standard error of least square means.

Levels of significance: NS, not significant; \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

Values with different lowercase superscripts within a row refer to significant differences between those groups ( $p < 0.05$ ).

**Table 3. Meat quality characteristics of the porcine *longissimus dorsi* muscle in groups defined by the live weight**

	Live weight			Level of significance
	Light	Medium	Heavy	
Muscle pH <sub>45 min</sub>	5.97 (0.05) <sup>1</sup>	6.00 (0.06)	5.90 (0.09)	NS
Muscle pH <sub>24 h</sub>	5.58 <sup>a</sup> (0.02)	5.60 <sup>a</sup> (0.02)	5.46 <sup>b</sup> (0.03)	*
Lightness ( $L^*$ )	47.1 (0.25)	47.3 (0.32)	47.4 (0.45)	NS
Redness ( $a^*$ )	7.24 <sup>a</sup> (0.18)	6.50 <sup>b</sup> (0.24)	4.69 <sup>c</sup> (0.42)	***
Yellowness ( $b^*$ )	3.31 (0.11)	3.34 (0.14)	3.78 (0.18)	NS
Drip loss (%)	4.33 (0.37)	4.63 (0.48)	4.01 (0.65)	NS
Filter paper fluid uptake (mg)	39.6 (3.05)	48.8 (3.97)	46.4 (5.42)	NS
Cooking loss (%)	20.5 <sup>b</sup> (0.31)	20.5 <sup>b</sup> (0.41)	22.1 <sup>a</sup> (0.55)	*
WBS (N)	43.6 (0.41)	43.4 (0.53)	43.3 (0.73)	NS
NPPC color score	2.37 (0.21)	2.50 (0.26)	2.31 (0.31)	NS
NPPC marbling score	2.12 (0.13)	2.25 (0.14)	2.42 (0.16)	NS

<sup>1</sup>Standard error of least square means.

Levels of significance: NS, not significant; \* $p < 0.05$ , \*\*\* $p < 0.001$ .

Values with different lowercase superscripts within a row refer to significant differences between those groups ( $p < 0.05$ ).

Abbreviations: WBS, Warner-Bratzler shear force; NPPC, national pork producers council.

nificant differences in NPPC color and marbling scores among the group.

Sensory quality is defined by the combination of a spectrum of sensory attributes including tenderness, juiciness, and flavor (Wood *et al.*, 2004). Among these attributes, tenderness is one of the most important characteristics and can be attributed to a consumer's perception of food quality (Choi *et al.*, 2012; Dransfield, 1994; Wood *et al.*, 1996). There were no significant differences observed in tenderness attributes, softness, initial tenderness, chewiness, rate of breakdown, and amount of perceptible residue (Table 4). Moreover, juiciness, flavor intensity, and off-flavor intensity were also similar among the groups ( $p > 0.05$ ).

## Discussion

Postnatal growth potential and ultimate muscle mass are largely determined by both the initial number of muscle fibers formed prenatally and the growth of individual muscle fibers during the postnatal period (Rehfeldt *et al.*, 2008). Generally, growth rate and muscle mass are positively correlated with both the number and area of muscle fibers (Choi *et al.*, 2013a; Ryu and Kim, 2005). Hence, meat-type pig, cattle, and chicken tend to have a higher number (fiber hyperplasia) and greater size (fiber hypertrophy) of muscle fibers (Fowler *et al.*, 1980; Picard *et al.*, 2006; Rehfeldt *et al.*, 2008). For example, Remignon *et al.*

**Table 4. Sensory quality characteristics of the porcine *longissimus dorsi* muscle in groups defined by the live weight**

	Live weight			Level of significance
	Light	Medium	Heavy	
Softness	5.98 (0.47) <sup>1</sup>	5.91 (0.53)	6.22 (0.71)	NS
Initial tenderness	5.78 (0.49)	5.73 (0.56)	5.99 (0.74)	NS
Chewiness	5.75 (0.52)	5.91 (0.58)	6.30 (0.77)	NS
Rate of breakdown	5.59 (0.40)	5.76 (0.44)	5.48 (0.61)	NS
Mouth coating	3.67 (0.20)	4.04 (0.22)	3.63 (0.36)	NS
Amount of perceptible residue	5.66 (0.21)	5.57 (0.23)	4.93 (0.37)	NS
Juiciness	5.23 (0.22)	5.50 (0.24)	5.35 (0.38)	NS
Flavor intensity	6.23 (0.21)	6.19 (0.24)	5.78 (0.38)	NS
Off-flavor intensity	5.95 (0.16)	5.97 (0.18)	6.26 (0.31)	NS

<sup>1</sup> Standard error of least square means. Levels of significance: NS, not significant.

Score distribution, low to high; softness, hard to soft; initial tenderness, tough to tender; chewiness, very chewy to very tender; rate of breakdown, very slow to very fast; mouth coating, very high to none; amount of perceptible residue, abundant to none; juiciness, not juicy to extremely juicy; flavor intensity, very weak to very strong; off flavor intensity, very weak to very strong.

(1995) showed that a fast growing chicken line with greater muscle mass exhibited more than 1.2 and 1.9 times greater the number and size of muscle fibers, respectively, compared to a slow growing chicken line with less muscle mass. The results from the current study support this notion. In this study, even though the conditions before and after slaughter were the same, each pig might have a different genetic capability to produce a greater muscle mass. The HW group exhibited an enhanced number and area of muscle fibers compared to the LW group.

On the contrary, no significant differences in total fiber number after birth have been observed in mammals or birds (Picard *et al.*, 2006; Rehfeldt *et al.*, 2008). Thus, muscle growth and mass in the postnatal period are primarily dependent on the rate of muscle fiber hypertrophy, since animals are slaughtered before the growth potential is exhausted (Rehfeldt *et al.*, 2000). In the case of Japanese quail, greater muscle mass of the heavier live weight line developed through selection from randomly bred control (RBC) birds was caused by muscle fiber hypertrophy, as total fiber number was not different between the heavy and RBC lines (Choi *et al.*, 2013b). In the current study, differences in loin eye area between the HW and MW groups was strongly associated with muscle fiber hypertrophy, especially type IIA and IIB fibers, rather than muscle fiber hyperplasia, whereas, differences in live weight and muscle mass between the MW and LW groups were associated with muscle fiber hyperplasia.

Pig performance has been improved by selection, and present-day meat-type pigs are the result of a long process of domestication (Rehfeldt *et al.*, 2008). This intense selection was accompanied by a change in the fiber type composition of muscles toward a higher proportion of

fast-twitch glycolytic fibers and a lower proportion of slow-twitch oxidative fibers (Rehfeldt *et al.*, 2008). Hence, a higher proportion of larger type IIB fibers are associated with heavier live weights and greater muscle mass (Choi *et al.*, 2013b; Rehfeldt *et al.*, 2008; Ruusunen and Puolanne, 2004). Increased carcass weight was also associated with a higher percentage of type IIB fiber (Kim *et al.*, 2013). In this study, even though the area of type IIB fibers was related to carcass characteristics, fiber type composition had a limited effect on live weight and loin eye area, as no significant difference was observed in the proportion of type IIB fibers among the groups.

Metabolic and morphological characteristics of muscle fibers are the major factors that influence the meat and its sensory quality characteristics (Choi and Kim, 2009; Rehfeldt *et al.*, 2008). Type I fibers contain a higher amount of lipids and predominantly use lipids and free fatty acids as a source of oxidative metabolic fuel. These fibers also contain a higher amount of myoglobin and lower amount of glycogen compared to type IIA and IIB fibers (Pette and Staron, 1997). Thus, porcine muscles containing a higher percentage of type I fibers exhibited more red color on its surface, higher muscle pH in the early postmortem period, and less fluid exudate compared to porcine muscles with a higher percentage of the larger type IIB fibers (Choi *et al.*, 2013a). Further, muscles with a higher total fiber number tended to exhibit higher pH<sub>45 min</sub> and lower drip loss compared to muscles with a lower total number of fibers, whereas greater fiber area was associated with increasing drip loss (Ryu and Kim, 2006). In this study, there was no significant difference in the proportion of type I or IIA fibers among the groups. Pigs having a higher growth rate exhibited higher lightness and shear force value compared

to pigs having a lower growth rate (Karlsson *et al.*, 1993). The HW group with its greater muscle fiber area and higher growth rate exhibited lower ultimate muscle pH and higher cooking loss compared to the MW and LW groups, but no significant differences were observed in drip loss or lightness among the groups, which are the most useful indicators of pork quality classification (Kaufman *et al.*, 1986). Similar results were reported by McGilchrist *et al.* (2016), who suggested that increased muscle mass was not always associated with higher glycolytic potential, pH in the early postmortem period, or meat color. Moreover, composition of fiber types are not correlated with live weights at slaughter (Jeong *et al.*, 2012). Jeong *et al.* (2010) suggested that tenderness attributes and juiciness after cooking were influenced by the WHC of fresh pork. In the present study, there were no significant differences in the WHC measurements with the exception of cooking loss. Trained panelists did not distinguish differences in the sensory quality characteristics among the groups.

### Conclusions

Taken together, increased live weight (an average live weight of 130.5 kg) in this study has limited effect on meat quality characteristics, and did not influence sensory quality attributes, including tenderness, juiciness, and flavor. Additionally, muscles with a greater number of medium or large size fibers tend to exhibit good carcass performance without impairing meat and sensory quality characteristics.

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