



Effects of Duroc Breeding Lines on Carcass Composition and Meat Quality

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Abstract

This study was performed to investigate the carcass composition and pork quality of Duroc breeding lines in Korea. A total of 200 Duroc pigs were used, and those were originated from four different great-grandparent (GGP) breeding stock farms (L1: N farm, L2: W farm, L3: S farm, L4: R farm). The carcasses of pigs from these farms were collected, and meat quality traits were evaluated. L1 and L2 had smaller carcass weights and thin backfat, whereas L3 and L4 had heavy carcass weights and thick backfat. L3 and L4 had higher contents of fat and protein than L1 and L2. For the meat quality characteristics, L1, L2, and L4 had higher pH values than L3. In addition, L4 had higher water holding capacity than the other lines. L4 had the highest sensory evaluation scores with regard to both juiciness and flavor. Consequently, the study results indicate that pork quality information from domestic Duroc breeding stock lines could be used to effectively improve pork quality in Korea.

Key words: Duroc, backfat thickness, pH, water holding capacity, sensory evaluation

Introduction

Economic development and increase in national income resulted in increased meat intake of Koreans. In 2012, there was an average consumption of 19.2 kg of pork, 9.7 kg of beef, and 11.6 kg of chicken per capita. In addition, pork consumption has steadily increased each year in Korea (MAFRA, 2014). Korean consumers tend to prefer marbled meat to lean meat. Highly marbled meat shows high lipid content. Intramuscular fat provides many sensory properties such as flavor and aroma volatiles, increase in tenderness and juiciness, and supplement of essential fatty acids (Kang *et al.*, 2010; Ngapo *et al.*, 2012a, 2012b). It is clear that intramuscular fat has a significant impact on meat quality characteristics. Moreover, some factors that affect meat quality characteristics include sex, species, age, feed, and environmental conditions. These factors affect meat quality characteristics including water holding capacity (WHC), meat color, pH, shear force, sensory characteristics, and storage character-

istics (Betram *et al.*, 2007; Channon *et al.*, 2004; D'Souza and Mullan, 2002; Wang *et al.*, 2014). Researchers at livestock research institutes and universities worldwide have conducted studies to improve meat quality characteristics and meat productivity (Knap *et al.*, 2001; Kolsstad *et al.*, 1996; Tizioto *et al.*, 2012).

In Korea, three-way crossbred pigs ([Landrace × Yorkshire] × Duroc) are mainly used for commercial purposes and have a large litter size, fast growth performance, and high meat yield (Kim *et al.*, 2006; Kim *et al.*, 2011; Park *et al.*, 1981). In Korea, the Duroc breed is used as a terminal sire when fattening pigs are produced. Additionally, this breed has both an excellent growth rate and higher intramuscular fat (Suzuki *et al.*, 2003). Duroc breeds imported from foreign countries are reared in domestic farms and the sperm is sent to commercial pig farms in Korea. However, meat quality and marbling forming ability in Duroc breeds were not compared using objective data, and exact meat quality information regarding breeding stock lines in Korea was not provided. Moreover, breeding stock businesses have been importing Duroc breeds from other countries. It is necessary to investigate the meat quality of Duroc lines and compare the meat qualities of lines in Korea. Therefore, the objective of this study is to investigate the pork quality of four

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Duroc breeding stock lines in Korea.

Materials and Methods

Animals and sampling

Pig breeding stock lines in this study were classified into four lines that are established domestic Duroc herds from respective great-grandparent (GGP) farms that were imported from foreign Duroc breeding stocks (Table 1). A total of 200 Duroc pigs were part of a pig improvement network program from November 2010 to December 2011 in the Korea Animal Improvement Association. At each of the farms, pigs were raised according to the Korean feeding standard for swine of the National Institute of Animal Science (2007). When the mean weight of pigs in a pen reached market weight, pigs were conventionally slaughtered and then chilled overnight. At 24 h postmortem, carcass traits including backfat thickness and carcass weight evaluated by the animal products grading service of Korea Institute for Animal Products Quality Evaluation (2001). The longissimus muscle from left side between the 5th and 13th rib was removed, and backfat was removed from the longissimus muscle. Then, meat qualities were evaluated at the Meat Science Laboratory of Chungbuk National University.

Carcass characteristics

The carcass weight and backfat thickness were measured based on the cold carcass grading system in the Korea Institute for Animal Products Quality Evaluation. The carcass length was measured from the 6th cervical vertebral to the H-bone on the left side.

pH

Using a homogenizer (Nihonseiki, Japan), 10 g of samples was homogenized in 100 mL of distilled water for 30 s at 7000 rpm. The pH levels of the homogenate were determined using a pH meter (Mettler Delta 340, Mettler-Toledo, Ltd., UK).

Meat color

The L*, a*, and b* values refer to the Hunter lab color system (L*=lightness, a*=redness, b*=yellowness) using a white fluorescent light (D65) as light source and were

determined on the surface of freshly cut meat after a 20 min bloom time using a Spectro Colormeter (Model JX-777, Color Techno. System Co., Japan) calibrated to the white plate (L*, 89.39; a*, 0.13; b*, -0.51). Each measurement was performed in six replicates, and the mean value was used as the assay result.

WHC

The centrifugation method described by Laakkonen *et al.* (1970) was used to measure WHC. Longissimus muscle samples (0.5±0.05 g) from each line were placed in a centrifugation tube with filter units, heated for 20 min at 80°C, and then cooled for 10 min. Samples were centrifuged at 2,000 g for 10 min at 4°C, and WHC was calculated as the change of sample weight.

Drip loss

A 2-cm-thick slice (weight, 100±5 g) cut from longissimus muscle was placed into a polypropylene bag and then vacuum packaged and stored for 24 h at 4°C. Drip loss was calculated as the weight difference of the samples.

Proximal analysis

The moisture, protein, fat, and ash contents were assayed according to the AOAC methods (1995).

Cooking loss

A 3 cm-thick slice (weight, 100±5 g) that was cut from the longissimus muscle was placed into a polypropylene bag, cooked for 40 min at 70°C in a water bath, and cooled to room temperature. Cooking loss was calculated by the weight difference of the samples.

Shear force

A 3 cm thick slice (weight, 100±5 g) cut from longissimus muscle was placed into polypropylene bag and then cooked for 40 min at 70°C in the water-bath and then cooled for 30 min. Samples were cut into 1 × 2 × 1 cm (width × length × height) pieces, and max weight was determined by a shearing, cutting test using a Rheo meter (Model Compac-100, Sun Scientific Co., Japan) under the following operational conditions: Table Speed of 110 mm/min, Graph Interval of 20 ms and Load Cell (max) of

Table 1. Classification of Duroc breeding stock lines in Korea

Terms	Line 1	Line 2	Line 3	Line 4
Great grandparents stock farms	N farm (Sweden, Ireland)	W farm (France)	S farm (France)	R farm (USA, Canada)

10 kg using Rheology Data System (RDS) Ver. 2.01.

Sensory evaluation

Well-trained in-house tasting panelists (n=5) evaluated sensory attributes of tenderness, juiciness, flavor, and overall acceptability using on a 5-point scale with 1 representing samples that were very tough, dry, mild, and unacceptable and 5 representing samples that were very tender, juicy, intense, and acceptable. The sample was independently evaluated by the panelists three different times.

Statistical analysis

Statistical analyses were carried out using the general linear model procedure of the Statistical Analysis System (SAS) Release 9.01 package (2002). Means were compared using the Duncan's multiple range test at a level of significance of $p < 0.05$ and the following model:

Comparison of Duroc breeding stock lines

$$y_i = \mu + \tau_i + \varepsilon$$

where,

y = observed value of the trait

μ = mean

τ = line effect (N farm, W farm, S farm, and R farm)

ε = random error

Results and Discussion

Carcass characteristics of Duroc breeding stock lines in Korea

The comparison of carcass characteristics in Duroc lines is explained in Table 2. Carcass weight was heavier in L4, whereas L2 was significantly lower ($p < 0.05$). In carcass length, L1 showed longer carcass length than the other lines ($p < 0.05$). The backfat thickness in Duroc lines was significantly higher in L3 than in the other lines, whereas L1 showed significantly thinner backfat thickness compared with that in the other lines ($p < 0.05$). Globally, Duroc pigs are used as a terminal sire to enhance

carcass weight and intramuscular fat (Channon *et al.*, 2004; Latorre *et al.*, 2003; Ruusunen *et al.*, 2012; Serrano *et al.*, 2008; Suzuki *et al.*, 2003). Most recently, Franco *et al.* (2014) reported that Celta crossed with Duroc lines had higher carcass yield as well as loin and ham percentage than pure Celta pigs (a Spanish native breed). Additionally, Bereskin *et al.* (1971) reported that the breed of the sire only significantly affected carcass length, but the breed of the dam significantly influenced all carcass traits including carcass length, backfat thickness, percentage of ham and loin, and loin-eye area. According to Soriano *et al.* (2005), comparison of carcass characteristics of progeny from Duroc sires in England, Spain, and Netherland revealed that Duroc progeny from the respective lines showed significant difference in carcass yield, carcass length, and backfat thickness ($p < 0.05$). Ramirez and Cava (2007) reported that progeny from different types of Duroc sires (DU1-high fattening type and DU2-meat production type) showed significant difference in carcass weight and backfat thickness ($p < 0.05$). DU1 progeny had higher carcass weight and backfat thickness compared with those of DU2 progeny. In this study, L3 and L4 had heavy carcass weights and thick backfat, whereas L1 and L2 had relatively light carcass weights and thin backfat. Moreover, Lonergan *et al.* (2001) reported that Duroc pigs that were selected for lean growth had significantly more lean gain, loin eye area, percentage lean, and less 10th-rib fat as well as backfat thickness.

Meat quality characteristics of the longissimus muscle of Duroc breeding stock lines in Korea

Meat quality characteristics of longissimus muscle from Duroc breeding stock lines are shown in Table 3. In chemical composition, L1 and L2 had significantly higher values in moisture and ash compared with L3 and L4. Alternatively, the protein contents of L1 and L2 were lower than those of L3 and L4 ($p < 0.05$). The highest fat content value among the longissimus muscle of Duroc breeding stock lines was observed in L3 ($p < 0.05$). In meat quality characteristics, pH_{24h} values ranged from 5.65 to 5.79, and L3 showed the lowest levels ($p < 0.05$). L4 showed a significantly higher WHC value than the other

Table 2. Carcass characteristics of Duroc breeding stock lines in Korea

Items	L1 (n = 50)	L2 (n = 61)	L3 (n = 51)	L4 (n = 38)
Carcass weight (kg)	85.88 ± 9.42 ^{bc}	83.55 ± 6.41 ^c	87.11 ± 4.09 ^b	97.86 ± 6.25 ^a
Carcass length (cm)	85.31 ± 3.29 ^a	77.82 ± 2.69 ^c	79.51 ± 5.41 ^c	82.04 ± 2.75 ^b
Backfat thickness (mm)	18.00 ± 4.52 ^d	22.32 ± 4.33 ^c	25.88 ± 3.38 ^a	24.13 ± 2.86 ^b

^{a-d}Means ± SD with different superscription within the same row differ ($p < 0.05$).

Table 3. Meat quality characteristics of the longissimus muscle of Duroc breeding stock lines in Korea

Items	L1 (n=50)	L2 (n=61)	L3 (n=51)	L4 (n=38)
Moisture (%)	73.61 ± 0.72 ^a	73.54 ± 0.84 ^a	72.38 ± 1.13 ^b	72.66 ± 0.99 ^b
Protein (%)	22.42 ± 0.57 ^b	22.52 ± 0.70 ^b	23.16 ± 0.76 ^a	23.24 ± 0.76 ^a
Fat (%)	2.78 ± 0.62 ^b	2.75 ± 0.79 ^b	3.41 ± 1.19 ^a	3.06 ± 1.10 ^{ab}
Ash (%)	1.17 ± 0.21 ^a	1.18 ± 0.39 ^a	1.04 ± 0.19 ^b	0.94 ± 0.15 ^b
pH _{24h}	5.75 ± 0.14 ^a	5.74 ± 0.13 ^a	5.65 ± 0.09 ^b	5.79 ± 0.22 ^a
WHC (%)	56.83 ± 3.38 ^c	58.52 ± 3.25 ^b	58.37 ± 4.28 ^{bc}	61.66 ± 4.59 ^a
Drip loss (%)	3.32 ± 0.86 ^b	3.78 ± 1.17 ^b	5.65 ± 0.09 ^a	3.42 ± 1.42 ^b
Cooking loss (%)	26.24 ± 1.93 ^c	27.82 ± 3.93 ^b	30.31 ± 2.59 ^a	26.60 ± 2.36 ^c
Shear force (kg)	1.28 ± 0.21 ^c	1.40 ± 0.22 ^b	1.63 ± 0.32 ^a	1.72 ± 0.37 ^a
Hunter color*	L	56.22 ± 2.36 ^a	54.89 ± 2.81 ^b	56.65 ± 2.45 ^a
	a	4.94 ± 1.19 ^{ab}	4.64 ± 1.04 ^b	4.68 ± 0.83 ^b
	b	7.99 ± 0.70 ^b	8.26 ± 0.95 ^b	8.04 ± 1.04 ^b

*L (lightness), a (redness), b (yellowness)

^{a-c}Means±SD with different superscripts within the same row differ ($p<0.05$).

lines, whereas L1 showed a lower WHC value compared with the other lines ($p<0.05$). With regard to cooking and drip loss, L3 had significantly higher values compared with the other lines ($p<0.05$). In shear force, L1 showed a significantly lower value compared with that of the other lines ($p<0.05$). In Hunter color, significant difference was observed among the lines. Lightness value was lower in L2 than in the other lines ($p<0.05$), whereas L4 showed significantly higher values of redness and yellowness compared with those of the other lines ($p<0.05$). Ramirez and Cava (2007) assessed the meat quality of longissimus muscle using different types of Duroc sires that were consisted of a Duroc line with a higher level of fattening and a Duroc line with a higher percentage of meat cuts and low carcass fat. In the results, longissimus muscle of Duroc lines with higher percentages of meat cuts and low carcass fat showed the worst meat quality in postmortem pH, cooking loss, drip loss, meat color, and showed the lowest percentages of intramuscular fat. Alternatively, Lonergan *et al.* (2001) reported that meat quality of longissimus muscle from Duroc pigs that were selected for lean growth were softer, more exudative, higher moisture content, higher shear force value, and less neutral lipid than control group. However, in that study, it was considered that L1 and L2 were of the lean growth type, which is not consistent with our report. In the study that was

conducted by Cilla *et al.* (2006), three lines of Duroc showed significant difference in fat content of the main cuts including ham, loin, shoulder, belly, and tenderloin ($p<0.001$). However, no significant difference was noted in meat quality parameters among Duroc lines.

Sensory evaluation of the longissimus muscle of Duroc breeding stock lines in Korea

Table 4 shows sensory evaluation of the longissimus muscle in Duroc breeding stock lines. Scores of attributes were expressed via a 5-point scale. Both tenderness and overall acceptability did not show significant differences. Alternatively, juiciness and flavor of L4 yielded higher scores compared with the other lines ($p<0.05$). Cilla *et al.* (2006) reported that dry-cured hams from pigs that were crossed with three types of Duroc sire lines (DU1-high intramuscular fat type, DU2-intermediate type, and DU3-lean and heavy type), and sensory analyses were conducted and acceptability was measured. As a result, dry-cured hams from DU1-sired pigs had higher overall acceptability. However, Ngapo *et al.* (2012a) determined that the degree of marbling did not influence the sensory scores of the pork neither roasted nor grilled, but the ageing method affected pork flavor and hardness. Lonergan *et al.* (2001) reported a comparison of meat quality between Duroc lines that were classified as either meat

Table 4. Sensory evaluation¹⁾ of the longissimus muscle of Duroc breeding stock lines in Korea

Items	L1 (n = 50)	L2 (n = 61)	L3 (n = 51)	L4 (n = 38)
Tenderness	3.14 ± 0.52	3.12 ± 0.41	2.99 ± 0.60	3.17 ± 0.69
Juiciness	3.04 ± 0.38 ^{ab}	3.14 ± 0.31 ^{ab}	2.99 ± 0.47 ^b	3.19 ± 0.55 ^a
Flavor	3.03 ± 0.32 ^b	3.08 ± 0.25 ^{ab}	3.08 ± 0.43 ^{ab}	3.20 ± 0.48 ^a
Overall acceptability	3.10 ± 0.38	3.11 ± 0.32	3.02 ± 0.45	3.16 ± 0.57

^{a,b}Means±SD with different superscription within the same row differ ($p<0.05$).

¹⁾1: very tough, dry, mild, and unacceptable, 5: very tender, juicy, intense, and acceptable.

production type or fat accumulation type. The line of the meat production type had significantly lower subjective firmness scores and was significantly more exudative. Moreover, shear force values were higher than those in the fat accumulation type. According to Steane (1986), it is generally accepted that an increased level of intramuscular fat has a positive influence on sensory qualities of pig meat and meat products.

Conclusion

Duroc pigs are commonly used as terminal sires in the commercial pig business. Therefore, we performed pork quality investigation of domestic Duroc breeding stock lines to help improve the development of pig breeding stock for the production of pork satisfied with consumers' needs. L1 and L2 possessed smaller carcass weights and thin backfat, whereas L3 and L4 had heavy carcass weights and thick backfat. The contents of fat and protein in L3 and L4 were higher than those in L1 and L2. With regard to meat quality characteristics, L1, L2, and L4 had higher pHs compared with L3. Additionally, L4 had a significantly higher WHC than the other lines. In sensory evaluation, L4 had the highest scores for both juiciness and flavor. Consequently, pork quality information from domestic Duroc breeding stock lines could be used to effectively improve pork quality.

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