

Comparison of Carcass Characteristics and Meat Quality between Duroc and Crossbred Pigs

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Abstract

This study was conducted to compare the carcass characteristics and meat quality characteristics of Duroc breed and crossbred pigs (Landrace × Yorkshire × Duroc, LYD). Duroc and crossbred pigs did not show differences in carcass characteristics. Crossbred pigs had higher moisture and protein content than Duroc breeds. However, Duroc breeds had a higher fat content than the crossbred pigs. In meat quality characteristics, crossbred pigs showed higher values of drip loss and cooking loss over Duroc breeds, while Duroc breeds showed higher ultimate pH value compared to that of crossbred pigs. However, there were no differences in water holding capacity and shear force value. In myoglobin content, crossbred pigs had higher content compared to that in the Duroc population. In subjective evaluation and sensory characteristics, Duroc breeds showed significantly higher scores in all categories except for tenderness over the crossbred pigs. However, in storage characteristics, Duroc breeds showed reduced tendency relative to crossbred pigs. Crossbred pigs had higher unsaturated fatty acid content than Duroc breeds did. In these results, Duroc breeds showed excellent meat quality characteristics with its higher intramuscular fat content and pH value, lower drip loss and cooking loss and higher juiciness and flavor, compared to the crossbred pigs.

Key words: Duroc, crossbred pigs, carcass characteristics, meat quality, USFA

Introduction

Pigs have been domesticated as a source of food for intake about 9,000 years ago. There are 30-40 species of domesticated pigs today (Rothschilds and Ruvinsky, 2010). In Korea, consumers prefer high marbled meat. Because marbled meat contains high lipid content, many sensory properties such as flavor and aroma volatiles and essential fatty acids. Tenderness and juiciness of meat are increased by those factors. It is clear that increase of fat in meat has a most significant effect on meat quality, though there are other factor (sex, species, age, feed, and environmental conditions) that affect meat quality. These factors include water holding capacity (WHC), color, pH, shear force, sensory attributes, and storage characteristics in meat. So, quality characteristics in meat have been

improved by studies of researchers at livestock research institutes and universities (Knap *et al.*, 2001; Kolstad *et al.*, 1996; Tizioto *et al.*, 2012).

The pig breeding stock industry is at the top of the pyramid structure of pig farms and plays an important role in providing superior genes to improve the pork industry. Thus, the ability to breed pig stock is the most important factor that influences the success or failure in the pig industry (Lee, 1996; Seo *et al.*, 2012). Currently, consumers prefer meat with excellent quality. Thus, in the three-way crossbreds, Landrace and Yorkshire are highly prolific and have a good mothering ability, and Duroc has good meat quality (Kim *et al.*, 2002; Kim *et al.*, 2006a; Seo *et al.*, 2011). Also, fertility and litter size are inherited through the maternal line, and meat productivity and meat quality are inherited through the paternal (Kim *et al.*, 2006b; Lee *et al.*, 2011). Therefore, the improvement of pig breeding stock is essential. On the other hand, Johnson *et al.* (2002) stated that average daily gain (ADG) is highest in Duroc. Among Hampshire, Landrace, Yorkshire and Duroc, respectively, ADG values of 0.83±0.13 kg, 0.85±0.15

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kg, 0.87 ± 0.14 kg, and 0.88 ± 0.13 kg were found during 100-177 d of age. Oh (2005) reported that the EMA (eye muscle area)'s heritability of Landrace, Yorkshire and Duroc were estimated to be 0.33, 0.18 and 0.37, respectively.

Three way crossbred pigs (Landrace \times Yorkshire \times Duroc) are mainly utilized for production of commercial pork and have more great production efficiency than pure or two-way crossbreds (Nelson and Robison, 1976). The Duroc breed is used as a terminal sire when commercial pigs are produced. Also, this breed has used for fattening of commercial pigs (Suzuki *et al.*, 2003). Therefore the objective of this study is to determine the carcass characteristics and meat quality characteristics between Duroc and crossbred pigs and to help pork industry in Korea.

Materials and Methods

Animals and sampling

A total of 620 pigs used in this study were comprised of 1) 200 purebred Duroc gilts, 2) 420 crossbred pigs in Korea. Duroc pigs were a part of pig improvement network program (Korea Animal Improvement Association, KAIA) at November 2010 to December 2011. Crossbred pigs (Landrace \times Yorkshire \times Duroc) were provided by Cheongwon Pig Farmers Corporation (CPFC) at March 2008 to February 2009. Pigs were raised by Korean Feeding Standard for Swine (KFSS) in the each farm. The basal diet was formulated to meet nutrient requirements of pigs and made of 51.43% corn, 18.72% wheat and wheat bran, 19.08% soybean meal, and 10.77% other feedstuffs and additives (Table 1). 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 measurements including backfat thickness, carcass length and carcass grading evaluated by Animal Products Grading Service (2001) were collected. Then, the *longissimus* muscle from left side between the 5th and 13th rib was removed and meat qualities were evaluated at meat science laboratory of Chungbuk National University.

Carcass characteristics

Carcass grade, carcass weight and backfat thickness were used from the data which was measured based on cold carcass grading system in the Korea institute for animal products quality evaluation (KAPE). Carcass length was measured from the 6th cervical vertebral to H-bone on the left side.

Table 1. Formula of basal diets

Ingredients	Finisher
Corn	51.43
Wheat	15.00
Wheat bran	3.72
Soybean meal	19.08
Molasses	4.00
Animal fat	4.00
C. Phosphate	1.16
Limestone	0.48
Salt	0.32
CuSO ₄	0.08
Methionine	0.03
Lysine	0.15
Antibiotic	0.20
Mix-Vitamin ¹⁾	0.11
Mix-Meneral ²⁾	0.10
Etc	0.14
Total	100.00
Calculated analysis (%)	
Crude protein	15.34
Crude fat	6.41
Crude ash	4.78
Crude fiber	2.98
ME (kcal/kg)	3,277

¹⁾Supplied per kg diets: Vitamin A, 8,000,000 IU; Vitamin D, 1,500,000 IU; Vitamin E, 40,000 ppm; Vitamin K 1,500 ppm; Thiamin, 1,000 ppm; Riboflavin, 4,000 ppm; Vitamin B₁₂, 20 ppb; Pyridoxine, 2,000 ppm; Niacin 20,000 ppm; Biotin, 30 ppm; Folic acid, 600 ppm

²⁾Supplied per kg diet: Se, 250 mg; I, 200 mg; Fe, 60,000 mg; Mn, 25,000 mg; Zn, 60,000 mg; Cu, 15,000 mg

pH

Using a homogenizer (Nihonseiki, Japan), 10 g of samples was homogenized in 100 ml of distilled water for 30 s at 7,000 rpm. The pH levels of the homogenate was determined using a pH meter (Mteeler Delta 340, Mettler-tolede, Ltd, UK).

Meat color

The L*, a* and b* values were determined on the surface of freshly cut meat after 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). L*, a*, b* values described Hunter lab color system (L*=lightness, a*=redness, b*=yellowness) using a white fluorescent light (D65) as light source. Each measurement was performed in 6 replicates, taking the mean value as the assay result.

Water holding capacity (WHC)

The centrifugation method described by Laakkonen *et*

al. (1970) was used to measure WHC. *Logissimus* muscle sample (0.5 ± 0.05 g) from each line were placed in 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 4°C and WHC calculated as the difference of sample weight.

Drip loss

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

Proximal analysis

Moisture, protein, lipid and ash were assayed according to the AOAC methods (1995).

Cooking loss

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

Shear force test

A 3 cm thick slice (weight 100 ± 5 g) cut from *logissimus* 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 $1 \times 2 \times 1$ cm (width \times length \times height) pieces and max weight were measured by a shearing, and 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 m/sec and load cell (max.) of 10 kg using the R.D.S (Rheology Data System) Ver 2.01.

Cholesterol

Freeze dried samples of 0.3 g were homogenized with 12 ml of chloroform:methanol (2:1) Folch solution and then placed for 24 h at 4°C . Ten ml of deionized water was added. After well mixed, samples were centrifuged at $3,000 \times g$ for 20 min 4°C . Lower phase of centrifuged samples were taken using a syringe and then placed in fume hood for 24 h, after completely evaporation, 1 ml of glacial acetic acid was added to the samples and vortexed for 30 s. Two ml of O-phthaldehyde reagent and 1 ml of H_2SO_4 were added to 0.1 ml of vortexed samples and then vortexed for 30 s. After 10 min, the absorbance was measured with a spectrophotometer (Optizen-3220UV, Meca-

sys, Korea) at 530 nm. Standard curve was described through that 10, 20, 30, 40, and 50 ml of cholesterol standard stock solution and 40, 30, 20, 10, 0 ml of glacial acetic acid mixed solution were measured by above procedure, respectively. And regression equation was obtained. Cholesterol content (mg/100g, dry wt.) was calculated following equation: measured amount by standard curve \times addition of glacial acetic acid \times diluted rate \times total lipid weight (mg) / sample weight.

Sensory characteristics

Well-trained in-house tasting panelists ($n=5$) evaluated sensory attributes of tenderness, juiciness, flavor and overall acceptability, using on a 5-point scale: 1-very tough, very dry, very mild, very unacceptable, 5-very tender, very juicy, very intense, very acceptable. The sample was evaluated independently by the panelists 3 different times.

Subjective evaluation

Well-trained in-house tasting panelists ($n=5$) evaluated subjective characteristics attributes of marbling, texture, meat color and total attribute, using on a 5-point scale: 1-extremely low in intramuscular fat, extremely bed in texture, very pale in meat color, extremely pale soft exudative (PSE), 5-very abundant in intramuscular fat, very good in texture, very dark in meat color, extremely dark firm dry (DFD). The samples were evaluated independently by the panelists 3 different times.

Myoglobin

Myoglobin content was measured by method of Krzywicki (1982) with modification. Two g of sample was homogenized by polytron (PT 3100, Kinematica AG, USA) with 18 ml of (4°C) 40 mM phosphate buffer (pH 6.8) for 30 s. After centrifuging the slurry at 5,200 rpm for 10 min, the fluid was filtered with Whatman No. 2 $\phi 150$ mm. Filtered fluid was measured by spectrophotometer (Optizen-3220UV, Mecasys, Korea) at 700 nm and 525 nm, respectively. The content of myoglobin was calculated using the equation:

$$\text{Myoglobin} = (A_{525} - A_{700}) \times 2.303 \times (18/\text{sample weight})$$

where A_λ = absorbance at λ nm.

Statistical analysis

Statistical analyses were carried out using the Generalized Linear Model (GLM) procedure of the SAS package (Statistical analysis system: The SAS system Release

9.01, 2002), Means were compared using the Duncan's multiple range test at a level of significance of $p < 0.05$. And the following model:

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

where,

y = observed value of the trait

μ = mean

τ = breeds effect (Duroc and LYD)

ε = random error

Results and Discussion

Comparison of carcass characteristics between Duroc and crossbred pigs

The results from comparing the carcass characteristics and grades between Duroc and crossbred pig are shown in Table 2. All carcass characteristics were not significantly different. Carcass weight, carcass length, and backfat thickness of Duroc and crossbred pigs were 87.76, 86.96, 81.10, 80.87, 22.49, and 22.17 respectively. In carcass grade, the incidences of grade 1+ and 1 were higher in the Duroc population than in LYD. In contrast, the incidences of grade A and B were higher in the LYD population. According to Huff-lonergan *et al.* (2002), carcass weight was significantly correlated with marbling, juiciness and off-flavor, and backfat thickness was correlated with marbling, firmness, tenderness, flavor and off-flavor. In addition, heavier and leaner carcasses are prone to show less marbling, are less firm, less tender and have reduced characteristics in pork flavor than carcasses that have smaller loin eye and thick backfat. According to the research result of Franco *et al.* (2014), crossbreeding imp-

Table 2. Comparison of carcass characteristics and carcass grade between Duroc and crossbred pigs (LYD)

Items	Duroc (n=200)	LYD (n=420)	
Carcass weight (kg)	87.76±8.46 ¹⁾	86.96±7.49	
Carcass length (cm)	81.10±4.91	80.87±2.97	
Backfat thickness (mm)	22.49±4.86	22.17±4.68	
Quality grade (%)	Grade 1+	23.84	7.69
	Grade 1	33.45	42.10
	Grade 2	42.70	50.20
Yield grade (%)	Grade A	39.16	44.00
	Grade B	27.27	34.66
	Grade C	32.86	14.00
	Grade D	0.69	7.33

LYD, Landrace × Yorkshire × Duroc, ¹⁾Mean±SE

proved the growth, carcass yield and percentage of lean meat because of higher ham development in the comparison of pure Celta pig and Celta pig crossed with Duroc. Also, Duroc breed tended to have thicker backfat and fat in muscle compared to Yorkshire breed (Enfalt *et al.*, 1997). Consistent with the results of this study, these results indicate that Duroc breed is good at production of high quality pork and crossbred breed is good at production of better yield.

Comparison of meat quality characteristics between Duroc and crossbred pigs

The comparison of meat quality characteristics of Duroc and crossbred pig are shown in Table 3. In chemical composition, moisture and protein contents were higher in crossbred pigs than in the Duroc population ($p < 0.05$). However, in fat content, the Duroc population showed a higher value than commercial pigs did ($p < 0.05$). No significant difference was observed in the ash content between the two species. In the comparison of meat quality from Duroc population and crossbred pigs, drip loss and cooking loss of *longissimus* muscle in the Duroc population were lower than in the crossbred pigs. Also, a higher pH_{24h} value was detected in Duroc population than in crossbred pigs. However, there were no differences in WHC and shear force value. In Hunter color, the Duroc population showed significantly higher yellowness compared to that in the crossbred pigs which in turn showed a higher value in redness ($p < 0.05$). In lightness, no signifi-

Table 3. Comparison of meat quality characteristics of the *longissimus* muscle between Duroc and crossbred pigs (LYD)

Items	Duroc (n=200)	LYD (n=420)	
Moisture (%)	73.09±1.06 ^b	73.75±1.16 ^a	
Protein (%)	22.79±0.78 ^b	22.99±1.22 ^a	
Fat (%)	2.98±0.97 ^a	2.19±0.81 ^b	
Ash (%)	1.09±0.28	1.10±0.37	
pH _{24h}	5.73±0.15 ^a	5.58±0.20 ^b	
WHC (%)	58.64±4.13	59.50±5.99	
Drip loss (%)	3.74±1.24 ^b	5.42±2.08 ^a	
Cooking loss (%)	27.84±3.29 ^b	30.29±3.33 ^a	
Shear force (kg)	1.49±0.33	1.44±0.39	
	L	55.80±2.76	55.05±5.61
Hunter color ¹⁾	a	4.85±1.00 ^b	5.19±1.47 ^a
	b	8.21±0.93 ^a	6.80±1.38 ^b
	Total cholesterol (mg/100 g)	96.61±44.43	97.32±43.00
Myoglobin (mg/100 g)	3.94±0.90 ^b	4.11±0.50 ^a	

¹⁾L, lightness; a, redness; b, yellowness

*LYD, Landrace × Yorkshire × Duroc

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

cant ($p>0.05$) differences were observed between the two species. Total cholesterol content of Duroc and crossbred pigs did not show significant differences. In myoglobin content, crossbred pigs had higher content compared to that in the Duroc population ($p<0.05$). Kim *et al.* (2008) investigated the effects of pig breed on meat quality of the *longissimus* muscle. LYD showed significantly higher lightness values compared to (Yorkshire \times Berkshire) \times Berkshire, British Berkshire, Kagoshima Berkshire, and Korean native black pig \times wild boars. Lloveras *et al.* (2008) reported a comparison of meat quality of offspring from sows (50% Landrace, 25% Yorkshire, and 25% Duroc) crossed with Duroc or Yorkshire pure breed boars. The offspring sired by Duroc showed better meat quality in WHC, shear force, tenderness, juiciness, and intramuscular fat content. After slaughter the pH and intramuscular fat content in the muscle is important values to evaluate the meat quality. Pork could be determined to normal or abnormal (pale soft exudative and dark firm dry meat) according to the pH in meat. So, pH is related to meat quality like as drip loss, color, WHC and palatability (Joo *et al.*, 1995; Kauffman *et al.*, 1993; Warner *et al.*, 1993; Van Laack and Smulders, 1992). Also, the intramuscular fat has an impact on meat quality including juiciness, tenderness, flavor and shelf-life in meat (Channon *et al.*, 2004; Garmyn *et al.*, 2011; Ramirez and Cava, 2007). Within this context, Duroc in the present study was better in meat quality (intramuscular fat, ultimate pH_{24h}, drip loss and cooking loss) than crossbred pigs as well.

Comparison of subjective evaluation and sensory characteristics of the *longissimus* muscle between Duroc and crossbred pigs

Table 4 shows the comparison of a subjective evaluation and sensory characteristics of *longissimus* muscle from Duroc and crossbred pigs. All items of the subjective evaluation were significantly higher in the Duroc population ($p<0.05$) than in the crossbred pigs. Furthermore, juiciness, flavor and overall acceptability, included in the sensory characteristics, were significantly different except for tenderness ($p<0.05$). According to Blanchard *et al.* (2000), eating quality (such as juiciness, tenderness, pork flavor, abnormal flavor and overall acceptability) was not affected by intramuscular fat from the loin of hybrid pigs sired by Duroc or Large white boars because other factors (such as proteolysis, sarcomere length and collagen content) may affect the tenderness of meats (Wheeler *et al.*, 2000).

Table 4. Comparison of subjective evaluation¹⁾ and sensory characteristics²⁾ of the *longissimus* muscle between Duroc and crossbred pigs (LYD)

Items	Duroc (n=200)	LYD (n=420)
Marbling	3.21±0.95 ^a	2.65±1.11 ^b
Texture	3.07±0.30 ^a	2.86±0.63 ^b
Color	3.13±0.29 ^a	3.01±0.61 ^b
Total attribute	3.03±0.17 ^a	2.85±0.44 ^b
Tenderness	3.10±0.55	2.99±0.78
Juiciness	3.08±0.43 ^a	2.97±0.63 ^b
Flavor	3.09±0.37 ^a	2.91±0.63 ^b
Overall acceptability	3.10±0.43 ^a	2.92±0.65 ^b

LYD, Landrace \times Yorkshire \times Duroc

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

¹⁾Marbling: 1, extremely low in intramuscular fat; 5, very abundant in intramuscular fat, Texture: 1, extremely bad in texture; 5, very good in texture, Meat color: 1, very pale in meat color, 5, very dark in meat color, Total attribute: 1, extremely PSE; 5, extremely DFD

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

Table 5. Comparison of fatty acid compositions of the *longissimus* muscle between Duroc and crossbred pigs (LYD)

Items	Duroc (n=200)	LYD (n=420)
Myristic acid (C14:0)	1.45±0.12	1.44±0.13
Palmitic acid (C16:0)	25.29±0.97 ^a	24.57±0.97 ^b
Palmitoleic acid (C16:1)	2.86±0.47	3.00±0.31
Stearic acid (C18:0)	14.72±1.37	13.78±1.32
Oleic acid (C18:1)	44.40±2.38	46.00±1.70
Linoleic acid (C18:2)	9.50±2.33	9.26±3.27
Linolenic acid (C18:3)	0.47±0.12	0.52±0.19
Eicosenoic acid (C20:1)	0.85±0.09 ^b	0.95±0.06 ^a
Arachidonic acid (C20:4)	0.43±0.23	0.44±0.09
Total saturated fatty acids	41.46±2.04 ^a	39.79±2.04 ^b
Mono-unsaturated fatty acids	10.41±2.39	10.23±3.49
Poly-unsaturated fatty acids	48.11±2.73	49.96±1.84
Total unsaturated fatty acids	58.53±2.04 ^b	60.20±2.04 ^a
USFA/SFA	1.41±0.11 ^b	1.51±0.13 ^a

LYD, Landrace \times Yorkshire \times Duroc

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

Comparison of fatty acid composition between Duroc and crossbred pigs

The comparison of fatty acid composition of *longissimus* muscle from Duroc and crossbred pigs is shown in Table 5. Significant differences were found in palmitic acid (C16:0) and eicosenoic acid (C20:1) contents. Palmitic acid (C16:0) content was significantly higher in the Duroc population than in the crossbred pigs. On the other hand, eicosenoic acid content (C20:1) was significantly higher in the crossbred pigs ($p<0.05$). Total saturated fatty acids of the Duroc population were higher than those in crossbred pigs. Total unsaturated fatty acids were higher

in crossbred pigs ($p < 0.05$). In addition, the ratio of unsaturated fatty acid to saturated fatty acid (USFA/SFA) showed significantly higher values crossbred pigs than in the Duroc population ($p < 0.05$). According to Raj *et al.* (2010), in a comparison of different breeds (Landrace, Duroc, Hampshire, and Pietrain) of pig, heavier pigs (130 kg body weight) showed higher saturated fatty acid content than did lighter pigs (90 and 110 kg body weight). Also, the content of saturated fatty acids was positively correlated with intramuscular fat and backfat. On the contrary, content of poly unsaturated fatty acid was negatively correlated with the presence of intramuscular fat and backfat. In addition, according to Lo Fiego *et al.* (2005), Pascual *et al.* (2006), and Bermudez *et al.* (2012), fatty acid composition in pigs could change according to nutritional components of the feed. In this study, there was no significant difference in carcass weight between Duroc and crossbred pigs ($p > 0.05$). Furthermore, Duroc with intramuscular fat content higher than that of crossbred pigs showed a higher saturated fatty acid content.

Conclusion

Duroc pigs are widely used as terminal sires in the pork industry. Therefore, we compared the carcass characteristics and meat quality characteristics between Duroc and crossbred pigs. Duroc and crossbred pigs did not show difference in carcass characteristics. Crossbred pigs had higher moisture and protein content than did Duroc breeds. However, Duroc breeds had a higher fat content than crossbred pigs. In meat quality characteristics, crossbred pigs showed higher values of drip loss and cooking loss than did Duroc breeds while Duroc breeds showed higher ultimate pH value compared to that of crossbred pigs. In a subjective evaluation and sensory characteristics, Duroc breeds showed significantly higher scores in all categories except for tenderness relative to crossbred pigs. However, crossbred pigs had higher USFA content of fatty acid composition than did Duroc breeds. As a result, Duroc breed were desirable in the meat quality characteristics due to higher intramuscular fat content and pH value, lower drip loss and cooking loss, even higher juiciness and flavor compared to crossbred pigs.

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