Characteristics of Carcass and Meat Quality for Landrace, Yorkshire, Duroc and their Crossbreeds

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랜드레이스, 요크셔, 듀록 및 교잡종에 대한 도체 및 육질특성

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적 요

순종 돼지와 교잡종 돼지의 도체 및 육질특성을 구명하기 위하여 랜드레이스 81두, 요크셔 123두 및 종료웅돈인 듀록 100두와 랜드레이스 × 요크셔의 교배로 생산된 F1 모돈 62두, 그리고 F1 모돈에 듀록 웅돈을 교배시켜 생산한 삼원교잡종 120두를 도축한 후 도체 특성을 측정하고, 좌도체 등심을 채취하여 육질 특성을 조사하였다. 생체중은 삼원 교잡종(LYD)이 가장 컸으며, 렌드레이스(LL)종이 가장 적었다. 도체율은 삼원교잡종이 가장 높았으며, 거래정육율은 요크셔종과 F1종이 가장 높았다. 등지방층 두께는 삼원교잡종이 가장 두꺼웠고, 렌드레이스종이 가장 얇았으며, 도체장은 F1종이 가장 길었고, 듀록종이 가장 짧았다. 일반조성분 중 조단백질 함량은 F1종이 다른 순종 및 삼원 교잡종 보다 높은 반면 듀록종이 가장 낮았다($p<0.05$). 조지방은 삼원교잡종과 듀록종이 다른 순종 및 F1종 보다 높은 함량을 보였다($p<0.05$). 사후 1시간 pH는 삼원 교잡종이 다른 순종 및 F1종에 비하여 높은 반면 사후 24시간 pH에서는 듀록종이 F1종 및 삼원 교잡종 보다 높게 나타났다($p<0.05$). 물리적 특성 중 전단력가는 삼원 교잡종이 랜드레이스에 비하여 연한 것으로 나타났고($p<0.05$), 보수성은 삼원 교잡종이 다른 순종 및 F1종에 비하여 높게 나타났다($p<0.05$). 가열감량은 F1종이 가장 높았고, 삼원 교잡종이 가장 낮았으며($p<0.05$), Purge loss는 듀록종이 원종, F1종 및 삼원 교잡종 보다 낮은 반면에 랜드레이스종이 가장 높았다($p<0.05$). 육색 중 L값은 랜드레이스종이 다른 순종, F1종 및 삼원 교잡종 보다 높았고, a값은 F1종과 랜드레이스종이 다른 순종 및 삼원 교잡종에 비하여 높았으며, b값은 랜드레이스종이 가장 높은 반면, 듀록종이 가장 낮았다. 관능평가 중 다즙성과 연도에서는 듀록종과 삼원 교잡종이 원종 및 F1종 보다 높았고($p<0.05$), 향미는 삼원 교잡종이 높은 평가를 받았다. 이상의 결과에서 듀록종과 삼원 교잡종은 다른 순종들과 F1종에 비하여 육질은 좋았으나 도체특성이 떨어지는 것으로 나타나 삼원 교잡종 생산에 있어 육질과 도체특성을 동시에 향상시킬 수 있는 최종 웅돈 품종을 찾아내기 위한 연구가 필요한 것으로 보인다.

(**Key words** : Crossbred, Carcass characteristics, Meat quality, Pigs)

Ⅰ. INTRODUCTION

Pork quality is a function of multi-factors including breed, feeding scheme, and pre- and post-slaughter managements. However, breed has been attributed as to the most significant single factor influencing sensory properties (Monin, 1983), and was also related to intramuscular fat, water-binding capacity, color and tenderness (Sellier and Monin, 1994).

It has been well documented that intramuscular fat positively influence juiciness, tenderness and flavour (Wood et al. 2003), as well as reduces shearing force required for mastication (Essen-Gustavsson et al., 1994). A number of sensory studies indicated that the effect of intramuscular fat on sensory attributes became detectable when pork chop contained greater than 2% of the fat (Bejerholm and Barton-Gade, 1986); while 2.5∼

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3% was necessary for the acceptable level of tenderness (Devol et al., 1988).

Duroc breed is known for higher intramuscular fat than other breeds (Barton-Gade, 1988), and for more a rapid growth rate than the Hampshire and the Yorkshire breed (Wilson and Johnson, 1981). For the reason, in pork industry of South Korea, approximately 60 % of the 15.3 million pigs annually slaughtered are composed of three-way crossbreds, with Duroc boar as terminal sire. However, there is no accessible information about productivity and meat quality traits of commercially used pure breeds and their crossbreds. Thus, the current study was designed to evaluate carcass traits and meat quality of Landrace, Yorkshire, Duroc, Landrace × Yorkshire (LY) and Landrace × Yorkshire × Duroc (LYD) crossbred pigs.

Ⅱ. MATERIALS & METHODS

1. Animals and experimental design

A total of 486 pigs used in this experiment comprised 81 Landrace (38 female, 27 male, 16 castration), 123 Yorkshire (60 female, 45 male, 18 castration), 100 Duroc (55 female, 45 male), 62 Landrace sires × Yorkshire dams crossbred (LY; 28 female, 22 male, 12 castration) and 120 Landrace-Yorkshire dams × Duroc sires crossbred (LYD; 54 female, 66 castration). Over 2 year of experimental period, pigs produced by the Darby Genetics Inc. under the same environmental condition with an identical diet. Landrace, Yorkshire and LY were produced and slaughtered in the spring and fall of the same year and Duroc and LYD were produced and slaughtered in the spring and fall of the same year. At approximately 96～108 kg live weight (approximately 180 days), 10～15 pigs were conventionally transported to the National Livestock Research Institute abattoir with minimum transit stress. After a 12 h resting, pigs were conventionally slaughtered over 25 consecutive days. Carcasses were chilled at 4ºC for 24 h. The following day the left sides were ribbed at the 11th/12 ribs, and back-fat thickness and loin muscle area were determined according to the method described by APGS (1995). Carcass length, carcass percentage and retail lean meat percentage were measured for the same side (Kim et al., 2002). pH was measured using a portable needle-tipped combination electrode (NWKbinar pH-K21, Germany) in the center of the muscle between the 3rd and 4th lumbar vertebrae at approximately 1 and 24 h postmortem.

2. Meat quality measurements

The following day after slaughter, *M. longissimus dorsi* (LD, from the 6th to 13th *vertebrae thoracicae*) was excised and taken to the meat science laboratory for determining moisture, protein, intramuscular fat, ash, WB shear force, Water-holding capacity, cooking loss, purge loss, meat color, and sensory characteristics. Percentage moisture, crude protein, intramuscular fat and ash were determined using the procedure of AOAC (1990). WB-Shear force was measured on cooked meat which was heated without cover in boiling water until an internal temperature of 75℃. Three cores (Ø 13 mm) cut along the fibre axis were taken from each sample and an average of 9 measurements was used for the final measurement (Park et al., 1999). Water-holding capacity was determined according to the filter paper method described by Grau and Hamm (1952, 1956) with slight modifications. Briefly, 0.5g of muscle tissue was placed on glass, and filter paper was pressed against the meat sample at 35～50 kg/cm^2 for 2 min. Water-holding capacity was calculated by using a planimeter. Percentage of cooking loss was calculated from weight loss during cooking for the WB-shear force measurement (sample weight, approximately 200 g) (Park et al., 1999). Purge loss was determined by weighing the muscle portions before vacuum-packaging and after 1 days at 4˚C to calculate percentage weight losses. Meat color determined by a Minolta Chromameter (CR300, Minolta, Japan) on freshly cut surface after a 30-min blooming at 4˚C. Sensory characteristics determined by 10 semi-trained panelists who were randomly selected from a total of 15 recruits. The panelists were asked to evaluate tenderness, flavor intensity and juiciness by a six-point assessment scheme (Park et al., 1999).

3. Statistic analysis

Differences between experimental groups for comparison of carcass and meat quality were tested using the General Linear Models (GLM) procedure of SAS (1998). Means were separated by Duncan's test ($p<0.05$).

Ⅲ. RESEULTS & DISCUSSION

1. Effect of breed on carcass traits

Table 1 presents carcass traits and percentage of retail lean meat. The results showed that carcass percent of LYD pigs had the highest dressing percentage with significantly ($p<0.05$) thicker back-fat, while Yorkshire and LY pigs showed significantly ($p<0.05$) higher retail lean meat percentages than other breeds. LY had the longest carcass length ($P<0.05$) among other breeds, whereby Duroc pigs were shortest. Loin eye area in the Yorkshire and LY pigs had significantly ($p<0.05$) larger than other breed with the smallest for Duroc pigs. Differences between breed of dam and breed of sire effects for backfat and loin eye area suggested that maternal effects are important for these traits (Wilken et al., 1992). Sigvardsson (1983) found that Duroc-sired pigs had a higher lean weight than Swedish Landrace-sired pigs. Lo et al. (1992) reported that Duroc-sired pigs had less backfat thickness and larger loin eye area than Landrace-sired pigs. On the other hand, pH at 1 h postmortem of LYD pigs was higher than other breeds, but the Yorkshire pigs had the highest pH at 24 hour postmortem ($p<0.05$). Both Goodwin (1995) and Steindel and Kaczmarek (1980) observed breed differences in ultimate pH. However, other studies (Enfalt et al. 1997; Essen-Gustavsson and Fjelkner-Modiz, 1985; Lo et al., 1992) failed to demonstrate breed differences in ultimate pH. In the latter study, Durocs did not differ from Landrace in ultimate pH.

In the chemical composition (table 1), less moisture content was found in LYD pigs compared with the other breeds, while protein content for LY pigs was higher than that for other breeds ($p<0.05$). An early study (Martel et al., 1988) showed that dry matter percentage was

Table 1. Mean and standard deviation for carcass quality from Landrace, Yorkshire, Duroc, LY and LYD crossbred pigs

Item	Landrace	Yorkshire	Duroc	LY†	LYD
Live weight (kg)	97.71^{c} ± 0.85	104.75^{a} ± 1.29	100.73^{b} ± 1.12	106.71^{a} ± 1.28	107.19^{a} ± 0.80
Carcass percentage (%)	73.41^{bc} ± 0.18	73.87^{b} ± 0.20	73.18^{c} ± 0.24	73.90^{b} ± 0.22	74.77^{a} ± 0.11
Retail lean meat (%)	50.29^{b} ± 0.20	52.13^{a} ± 0.26	47.79^{d} ± 0.16	51.94^{a} ± 0.27	48.63^{c} ± 0.19
Backfat thickness (cm)	1.82^{d} ± 0.05	1.97^{cd} ± 0.05	2.30^{b} ± 0.07	2.00^{c} ± 0.05	2.81^{a} ± 0.05
Carcass length (cm)	80.84^{b} ± 0.29	80.09^{b} ± 0.33	76.14^{d} ± 0.30	82.56^{a} ± 0.34	78.42^{c} ± 0.25
Loin eye area (cm^{2})	39.56^{c} ± 0.67	43.70^{a} ± 0.79	36.87^{d} ± 0.48	43.20^{a} ± 0.80	40.56^{b} ± 0.61
pH at 1h postmortem	6.27^{bc} ± 0.02	6.30^{ab} ± 0.02	6.21^{c} ± 0.02	6.25^{bc} ± 0.02	6.34^{a} ± 0.02
pH at 24 h postmortem	5.51^{c} ± 0.01	5.63^{a} ± 0.01	5.53^{bc} ± 0.01	5.55^{b} ± 0.02	5.55^{b} ± 0.01
Moisture (%)	74.65^{bc} ± 0.13	75.27^{a} ± 0.09	74.38^{c} ± 0.12	74.96^{ab} ± 0.19	73.53^{d} ± 0.11
Protein (%)	22.61^{b} ± 0.10	22.59^{b} ± 0.08	21.84^{c} ± 0.06	22.90^{a} ± 0.13	22.41^{b} ± 0.08
Fat (%)	1.70^{b} ± 0.16	1.09^{c} ± 0.08	2.76^{a} ± 0.14	1.09^{c} ± 0.13	2.82^{a} ± 0.11
Ash (%)	1.04 ± 0.01	1.05 ± 0.02	1.01 ± 0.01	1.06 ± 0.01	1.04 ± 0.00

† LY : Landrace × Yorkshire, LYD : Landrace × Yorkshire × Duroc.

ad : Values with different superscripts in the same row differ significantly ($p<0.05$).

higher in Duroc crossbreds than in the Yorkshire, Landrace, and Hampshire crossbreds, but protein percentage was the lowest in Duroc crossbreds. Fat content for LYD and Duroc pigs was significantly ($p<0.05$) higher than that for other breeds. Present results were in agreement with reports that the meat from Durocs and Duroc sired pigs contained more intramuscular fat than from Yorkshires and Yorkshire sired pigs (Enfalt et al., 1997; Wood et al., 1996). Barton-Gade (1988) reported that intramuscular fat contents of 3.21, 1.58, 1.59, and 1.86% for Duroc, Landrace, Large White and Hampshire breed pigs, respectively. Sellier (1988) concluded that Duroc pigs generally showed a markedly higher intramuscular fat content than Large White or Landrace pigs (+2% on average). McGloughlin et al. (1988) evaluated the Duroc breed as a terminal sire and reported that Duroc crosses had significantly less backfat but higher intramuscular fat content (2.9%) than Irish Landrace × Large White crosses (2.0%). There were no appreciable differences in percentage of ash content in the LD muscle from all breeds.

2. Effect of breed on objective and subjective meat quality

Table 2 compares objective and subjective meat quality between the breeds. LYD pigs were lower shear force values compared with that from other breeds and demonstrated the best water holding capacity among breeds ($p<0.05$). Jeremiah et al., (1999) reported that the meat from Landrace and Yorkshires had higher shear force values than the meat from Durocs. Also, Enfalt et al., (1997) reported that the meat from Duroc sired pigs was more tender than the meat from Yorkshire sired pigs. Concerning cooking loss and purge loss, the LD muscle from LYD and Duroc pigs was significantly lower compared with that from other breeds, respectively ($p<0.05$). However, Lo et al. (1992) reported that there were no significant differences between Duroc and Landrace pigs for most of the objective measurements of loin muscle quality (i. e., cooking loss, shear value, and water-holding capacity). Also, drip loss was higher in meat from Duroc pigs in one report (Smith and Pearson, 1986) but subsequent studies failed to confirm this (McGloughlin et al., 1988; Martel et al., 1988).

In the measurement of objective meat color, hunter *L** value was lower for LYD pigs when compared to that from other breeds ($p<0.05$). Hunter *a** value was higher in LY pigs than in other breeds ($p<0.05$) and hunter *b** value was the highest for Landrace pigs ($p<0.05$). Langlois and Minvielle (1989) found Hampshire and Duroc

Table 2. Mean and standard deviation for meat quality of *Longissimus* muscle from Landrace, Yorkshire, Duroc, LY and LYD crossbred pigs

Traits	Landrace	Yorkshire	Duroc	LY	LYD
Shear force (0.5in.^{2}/kg)	$4.19^{a} \pm 0.68$	$3.98^{ab} \pm 0.12$	$3.66^{ab} \pm 0.12$	$4.02^{ab} \pm 0.18$	$3.47^{b} \pm 0.09$
Water holding capacity (%)	$53.64^{c} \pm 0.41$	$52.56^{c} \pm 0.36$	$58.33^{b} \pm 0.44$	$52.95^{c} \pm 0.41$	$61.66^{a} \pm 0.30$
Cooking loss (%)	$37.01^{ab} \pm 0.81$	$36.86^{b} \pm 0.31$	$36.87^{b} \pm 0.27$	$38.11^{a} \pm 0.35$	$35.00^{c} \pm 0.32$
Purge loss (%)	$4.31^{a} \pm 0.34$	$3.19^{b} \pm 0.31$	$1.37^{d} \pm 0.17$	$2.87^{b} \pm 0.32$	$2.10^{c} \pm 0.12$
Hunter L	$49.63^{a} \pm 0.75$	$47.79^{ab} \pm 0.50$	$46.23^{bc} \pm 0.36$	$48.56^{ab} \pm 1.49$	$44.72^{c} \pm 0.28$
Hunter a	$7.13^{ab} \pm 0.30$	$6.15^{ab} \pm 0.28$	$5.58^{b} \pm 0.11$	$7.33^{a} \pm 0.60$	$6.02^{ab} \pm 0.12$
Hunter b	$5.39^{a} \pm 0.26$	$4.29^{bc} \pm 0.20$	$3.88^{c} \pm 0.09$	$4.96^{ab} \pm 0.54$	$4.35^{bc} \pm 0.10$
Juiciness*	$3.44^{b} \pm 0.06$	$3.49^{b} \pm 0.06$	$4.12^{a} \pm 0.05$	$3.58^{b} \pm 0.09$	$3.98^{a} \pm 0.05$
Tenderness	$3.63^{b} \pm 0.08$	$3.61^{b} \pm 0.07$	$4.17^{a} \pm 0.08$	$3.61^{b} \pm 0.13$	$4.15^{a} \pm 0.07$
Flavor	$4.06^{c} \pm 0.05$	$4.02^{c} \pm 0.04$	$4.31^{b} \pm 0.04$	$4.11^{c} \pm 0.06$	$4.48^{a} \pm 0.04$

For other abbreviations see Table 1.
a-d : Values with different superscripts in the same row differ significantly ($p<0.05$).
* Based on 6-point evaluation (Juiciness, 1 = very dry, 6 = very juicy; Tenderness, 1 = very tough, 6 = very tender; Flavor, 1 = very objectionable, 6 = very acceptable).

breeds generally had a darker meat color than Yorkshire and Landrace breeds. In contradiction, Wood et al. (1996) reported the color of *M. longissimus thoracis et lumborum* from Duroc and Large White pigs was not significantly difference between breeds.

In the sensory properties, juiciness and tenderness scores were higher in Duroc and LYD pigs than in other breeds ($P<0.05$). LYD pigs received the highest ($P<0.05$) flavor scores. These results could be anticipated because Duroc and LYD had much more fat than the other breeds. Present results are in agreement with reports that the meat from Durocs was perceived to be more juicy than the meat from Landrace and Yorkshires and had a more desirable flavor than the meat form Landrace and Yorkshires (Jeremiah et al., 1999). Also, Danish researchers found that the Duroc had higher levels of intramuscular fat than other breeds and also had associated positive effects on meat flavor, tenderness, and juiciness (Barton-Gade and Bejerholm, 1985; Bejerholm and Barton-Gade, 1986). Ellis et al. (1990) reported improvements in juiciness and overall acceptability associated with higher intramuscular fat content. However, Edwards et al. (1988) detected no significant breed effects for any eating quality trait, although the proportion of intramuscular fat in loin chops was greater for Duroc-than for British Large White-sired pig. Collectively, the current study showed that the meat from Duroc purebred and LYD crossbred pigs had improved meat quality (e.g. fat percentage, shear force, purge loss and sensory), however they had lower carcass pro-ductivity when compared to the other breeds. The further study on the establishment of cross-bred pigs produced from different terminal sire breeds are necessary to produce pork with high acceptance in meat quality as well as carcass yields.

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