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ARTICLE

# Effects of Carcass Weight and Back-fat Thickness on Carcass Properties of Korean Native Pigs

Gye-Woong Kim* and Hack-Youn Kim*

*Department of Animal Resources Science, Kongju National University, Yesan 32439, Korea*

## Abstract

Our study analyzed the carcass properties of 170 Korean native pigs in relation to carcass weight and back-fat thickness to provide general data for the production and distribution of high quality pig meat. The 70-74 kg group showed highest yield (73.41%). The ≥80 kg group showed the highest thickest back-fat (24.13 mm) ($p$<0.05). The ≥80 kg group showed the best quality grade (1.00). Back-fat thickness showed significant differences in the weight among groups ($p$<0.05). The ≥25 mm group showed the highest carcass weight (75.93 kg). The thickest back-fat group (≥25 mm) showed the highest yield (73.03%). There were significant differences in back-fat thickness among groups ($p$<0.05), and the ≥25 mm group showed the highest thickness back-fat (27.60 mm). We found a strong positive correlation between carcass weight and back-fat thickness (r=0.346) as well as meat quality grade (r=0.739). Back-fat thickness had a relatively strong positive correlation with meat quality grade (r=0.444). Therefore, there are required to manage the breeding through selection of excellent native species for increasing their carcass weight and enhance meat quality.

**Keywords** carcass properties, carcass weight, back-fat thickness, Korean native pigs

## Introduction

High quality pork, which indicates fresh, bright red color, desirable texture including springiness, can be produced under appropriate feeding management and marketing time (Choi *et al*., 2005; Kim and Lim, 2006; Lee *et al*., 1996). Such a high quality pork has been produced primarily with meat that exhibits low back-fat and body fat, with excellent feed efficiency and meat productivity (Choi *et al.*, 2004; Kim, 2012; Larzul *et al.*, 1997).

Sex and age at marketing have been reported to affect carcass characteristics and meat quality of finishing pigs (Choi *et al.*, 2000; Kim, 2012). In addition, the carcass weight as well as back-fat thickness have been reported to affect carcass grading and properties (Park *et al.*, 2005; Park *et al.*, 2009). Leaner pig meat is associated with greater meat loss, lower fat firmness, and less juiciness and flavor (Choi *et al.*, 2005; Hah *et al.*, 2005; Kim, 2012).

Carcass weight, marbling, tenderness, and meat color are important carcass grading criteria (Jin *et al.*, 2004; Kim and Kim, 2009; Kim *et al.*, 2010; Park *et al.*, 2007). Furthermore, pork quality is influenced by pig breed, feeding method, nutritional status, slaughtering method, and processing. Pig breed is known to have a great impact on meat quality (Cho *et al.*, 2007a; Martens, 1998; Oh *et al.*, 2008; Warris *et al.*, 1995). For instance, the Jeju native pigs have adapted themselves to the climate and natural environment of South Korea over the years (Cho *et al.*,

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***Corresponding authors**
Gye-Woong Kim
Department of Animal Resources Science, Kongju National University, Yesan 32439, Korea
Tel: +82-41-330-1245
Fax: +82-41-330-1249
E-mail: kimgoong@kongju.ac.kr

Hack-Youn Kim
Department of Animal Resources Science, Kongju National University, Yesan 32439, Korea
Tel: +82-41-330-1241
Fax: +82-41-330-1249
E-mail: kimhy@kongju.ac.kr

2007a; Choi *et al.*, 2005). Studies have reported that the presence of thin and abundant muscle fibers in Jeju native pigs renders more meat color, white fat and tenderness than those of the other breeds (Cho *et al.*, 2007a; Jin *et al.*, 2001). However, it has been never reported for correlation between carcass traits such as carcass weight or back-fat thickness and meat quality traits in Jeju native pigs.

In this study, we categorized the carcass grades of 170 Korean native pigs by their weight and back-fat thickness to examine various carcass properties, ultimately aiming to provide foundational data to manage the breeding through selection of excellent native species for production of high quality pork.

## Materials and Methods

### Animals and samples

Korean native pigs in Jeju (170: 116 castrates and 54 gilts) were reared by commercial diet according to National Research Council Nutrient requirements. All the pigs were transported into a commercial slaughterhouse under the same handling conditions at around 210 d of age and were slaughtered under the supervision of the Korean grading service for animal products. At 24 h postmortem, carcass traits including back-fat thickness and carcass weight were evaluated by the animal products grading service of Korea Institute for Animal Products Quality Evaluation. The *longissimus* muscle was deboned from carcass and then back-fat was removed from the *longissimus* muscle. Then, meat quality properties were evaluated at the Meat Science Laboratory of Kongju National University. Each pig was classified into four categories of carcass weight as well as back-fat thickness (Table 1).

### Carcass properties

Korean native pigs that were reared in a pig N farm were slaughtered and skinned at the Jeju H slaughterhouse, after which the grader had classified the carcasses based on a four-level grading scheme (including unrated; data not presented). The warm half-carcass weight was recorded, and the last rib of the precooled (5°C) carcass was cut vertically to measure the depth of the fat layer for analysis of back-fat thickness.

Surface meat color was measured on the split loin area using a color meter (Model NF333, Nippon Denshoku Co., Japan). Three repeated measurements of Hunter L* (lightness), a* (redness), and b* (yellowness) were recorded against a white reference plate (Y=92.40, x=0.3136, y=0.3196) and the average of the three values presented. The Korean pork color standard chart (No-7 steps) was used to score the pork from 1 (very light) to 7 (very dark). Marbling was measured by scoring the intramuscular fat content of *longissimus* muscle chops on the scale from 1 (low marbling) to 5 (high marbling) as per the marbling standard (No-5 steps). The pH of the carcass was measured by inserting the pH probe (Model S220, Mettler-Toledo, Switzerland) directly into the center of the loin. A three-level grading scale was used to grade the quality of the meat (1 point for grade 1+, 2 points for grade 1, and 3 points for grade 2).

**Table 1. Distribution of Korean Native Pigs according to carcass weight and back-fat thickness**

| | | Number (N=170) | % |
|---|---|---|---|
| Carcass weight (kg) | < 70 | 40 | 23.81 |
| | 70-74 | 64 | 38.10 |
| | 75-79 | 48 | 28.57 |
| | ≥ 80 | 18 | 10.59 |
| Back-fat thickness (mm) | < 15 | 12 | 7.06 |
| | 15-19 | 52 | 30.95 |
| | 20-24 | 76 | 45.24 |
| | ≥ 25 | 30 | 17.86 |

### Statistical analysis

The means and standard deviations were calculated using the General Linear Model (GLM) procedure of the SAS statistical package (SAS, Inc., USA). Duncan's multiple range test was used to compare means of each item among carcass weight and back-fat thickness groups at a 5% significance level. The procedure CORR of the SAS package was used to calculate correlations among carcass characteristics.

## Results and Discussion

### Carcass properties in relation to carcass weight

The carcass properties among different weight groups are shown in Table 2. The mean carcass weight was 72.94 kg across all groups. The mean carcass weight was 66.00 and 81.63 kg for the <70 and ≥80 kg groups, respectively, indicating a significant difference in the weight among the carcass weight groups ($p$<0.05). These values were higher than those reported for Korean native pigs by Cho *et al.* (2007a), wherein the lightest group weighed 46.69 kg and the heaviest group weighed 65.63 kg. These results reflect the growingly heavier marketing weights of

**Table 2. Carcass characteristics by carcass weight groups**

| Traits \ Carcass weight (kg) | < 70 (N=40) | 70-74 (N=64) | 75-79 (N=48) | ≥ 80 (N=18) | Average±S.D. |
|---|---|---|---|---|---|
| Carcass weight (kg) | 66.00±3.17$^{d}$ | 72.25±1.26$^{c}$ | 76.75±1.35$^{b}$ | 81.63±1.46$^{a}$ | 72.94±5.17 |
| Carcass % | 71.51±1.49$^{b}$ | 73.41±0.98$^{a}$ | 71.83±0.86$^{b}$ | 72.97±0.60$^{b}$ | 72.46±1.35 |
| Back-fat thickness (mm) | 18.75±4.54$^{c}$ | 21.34±4.62$^{b}$ | 21.29±2.94$^{b}$ | 24.13±3.40$^{a}$ | 20.98±4.31 |
| Hunter L* | 38.83±3.02 | 38.00±4.31 | 37.7±2.98 | 38.19±5.40 | 38.14±3.80 |
| Hunter a* | 4.68±1.31 | 4.76±2.00 | 4.72±1.60 | 4.26±0.81 | 4.68±1.65 |
| Hunter b* | 6.24±1.05 | 6.05±1.31 | 6.02±1.21 | 5.60±1.12 | 6.04±1.21 |
| pH | 5.61±0.10 | 5.59±0.14 | 5.64±0.12 | 5.60±0.20 | 5.61±0.13 |
| Visual color (1-7) | 3.30±0.65$^{b}$ | 3.59±1.12$^{ab}$ | 3.92±0.82$^{a}$ | 3.50±1.50$^{ab}$ | 3.61±1.00 |
| Marbling scores (1-5) | 3.25±1.32 | 3.09±1.24 | 3.67±1.42 | 3.75±1.00 | 3.36±1.31 |
| Meat quality grades ($1^{+}$-2) | 2.35±0.48$^{d}$ | 2.13±0.33$^{c}$ | 1.29±0.46$^{b}$ | 1.00±0.00$^{a}$ | 1.83±0.64 |

All values are the mean±standard deviation.
$^{a-c}$Values with the different superscripts are significantly different ($p$<0.05).

Korean native pigs as a result of improved efficiency in the management of age at marketing and feeding.

The average of carcass yield was 72.46% and the highest yield (73.41%) recorded for the 70-74 kg group. A significant difference in the carcass yield was observed among the carcass weight groups ($p$<0.05). The 70-74 kg group showed the highest yield (73.41%). These results showed similar trend comparing with those observed by Choi (2005) and Cho *et al.* (2007a). Choi (2005) reported a carcass yield of 72.32% and 75.87% for Korean native pigs and a crossbreed (LYD: Landrace × Yorkshire × Duroc), respectively, while Cho *et al.* (2007a) recorded a carcass yield of 71.95% for the >65 kg group. The lower carcass yield for Korean native pigs compared to crossbreeds may be associated with the lower weight at marketing or slaughter.

The average of back-fat thickness was 20.98 mm. A significant difference in the back-fat thickness was observed among the carcass weight groups ($p$<0.05), with the highest and the lowest value recorded for the ≥80 kg (24.13 mm) and <70 kg (18.75 mm) groups, respectively. Our observations are similar to those reported by Park *et al.* (2005), where the back-fat thickness of Korean native pigs and a crossbreed (LL: Landrace-Landrace) was 24.3 mm and 21.0 mm, respectively. Kim and Kim (2009) also showed similar results with back-fat thickness for a crossbreed (LYD) ranging from 22.9-24.5 mm. These results suggest that there are no remarkable differences in the back-fat thickness among breeds.

With respect to meat color, the mean L*, a*, and b* values were respectively 38.14, 4.68, and 6.04 the group depending on meat color were no significant difference among the carcass weight groups. Cho *et al.* (2007a) reported that marketing and carcass weight show no significant effect on meat color. On the contrary, Choi *et al.* (2007) showed that in comparison to a crossbreed, Korean native pigs displayed lower L* and b* values but higher a* values, suggesting a difference in meat color among breeds.

The average pH was 5.61 and the group depending on pH were no significant difference among the carcass weight groups. Similar observation was reported by Park *et al.* (2005), where the pH of Korean native pigs and a crossbreed (LL) were 5.61 and 5.51, respectively, thereby indicating no significant difference in pH among different weight groups or breed. In agreement with our result, Oliver *et al.* (1993) also reported that pH does not vary significantly across breeds.

The average visual color based on the meat color plate was 3.61 and the groups depending on visual color was only significant difference between <70 kg and 75-79 kg groups ($p$<0.05). Heavier carcasses were darker, while the <70 kg group exhibited light color (3.30). These results supported the finding by Cho *et al.* (2007b) that heavier carcasses display higher redness values, which is presumably an important carcass-grading criterion.

The average marbling score was 3.36 and the groups by marbling scores were no significant difference observed among the carcass weight groups. Previous study by Kim and Kim (2008) concluded that heavier weight at slaughter was associated with higher marbling in a crossbreed (LYD). In addition, Kim and Lim (2006) showed that heavier carcasses were associated with higher marbling. Although our study showed contradictory result with the previous study, the increase in carcass weight was observed by a trend of increase in the carcass marbling score.

The average meat quality grade was 1.83 and the grades were a significant difference among the weight groups ($p$ <0.05). Heavier carcasses were associated with lower values on the quality grade (good), while the <70 kg group displayed a relatively higher value on the quality grade (2.35, poor). Our results coincided with those reported by Jin *et al.* (2005) who showed that the final carcass grade in Korean native pigs was higher for heavier carcasses. On the contrary, Kim (2012) found that the majority of the 78-84 kg group was grade 1+, while the >85 kg group was grade 2 in crossbreeds (LYD or YLD). The fact that Korean native pigs were assessed depending on the same carcass grading criteria used for crossbreeds may have contributed to the difference in the results.

## Carcass properties in relation to back-fat thickness

The carcass properties of Korean native pigs among different back-fat thickness groups were shown in Table 3. The average carcass weight was 72.94 kg across all groups. Carcass weights showed significant differences among back-fat thickness groups ($p$<0.05). The mean carcass weights of the ≥25 mm and <15 mm groups were 75.93 and 69.20 kg, respectively, which carcass weight was proportional to back-fat thickness. These results showed similar trend comparing with those observed by Kim and Lim (2006), which indicated a positive correlation between carcass weight and back-fat thickness in crossbreeds (LYD, finishing pigs).

The mean carcass yield was 72.46%, with a significant difference among the groups. The highest carcass yield (73.09%) was recorded for the group with highest back-fat thickness. Park *et al.* (2005) showed an increase in the carcass weight and yield with increase in the back-fat thickness in Korean native pigs, which may be attributed to the breed-specific characteristics of pigs.

The mean back-fat thickness was 20.98 mm across all groups. The mean back-fat thickness of the ≥25 mm group was 27.60 mm, which was significantly higher than those reported for other groups ($p$<0.05). The <15 mm group displayed the lowest level of back-fat thickness (mean 11.40 mm). Park *et al.* (2005) reported that heavier Korean native pigs tend to have thicker back-fat, though not statistically significant.

For meat color, the mean Hunter L* (lightness) and a* (redness) values were 38.14 and 4.68, respectively, with no significant difference among the back-fat thickness groups. On the other hand, the mean b* (yellowness) value was 6.04, with significant differences among the groups ($p$<0.05). Thicker back-fat was associated with higher b* values, and the <15 mm group had the lowest b* value (5.25). Since the decreases of back-fat thickness and carcass weight caused the increase of lightness, but the decreases of yellowness and redness, lightness were in inverse proportion to yellowness and redness. In agreement with our results, Jeremiah *et al.* (1999), Sather *et al.* (1991), Kim *et al.* (2000), and Oh *et al.* (2008) reported that there is no difference in meat color across breeds. On the contrary, Park *et al.* (2005) showed that CIE L*, a*, and b* values significantly varied by breed or age at marketing, necessitating additional studies for more accurate results.

The average pH was 5.61 across all groups and the groups depending on pH values were no significant differences observed among the groups. The ≥25 mm group had the highest pH (5.66) with no consistent trend. Park *et al.* (2009) observed no significant variation in the pH with respect to back-fat thickness in crossbreeds. Cho *et al.* (2007a) observed similar results in Korean native pigs

**Table 3. Carcass characteristics by back-fat thickness**

| Traits \ Back-fat thickness (mm) | | < 15 (N=12) | 15-19 (N=52) | 20-24 (N=76) | ≥ 25 (N=30) | Average±S.D. |
|---|---|---|---|---|---|---|
| Carcass weight (kg) | | 69.20±4.69$^{c}$ | 72.19±5.10$^{b}$ | 72.76±5.32$^{b}$ | 75.93±3.65$^{a}$ | 72.94±5.17 |
| Carcass % | | 72.07±0.55$^{b}$ | 72.20±1.35$^{b}$ | 72.48±1.52$^{ab}$ | 73.03±0.83$^{a}$ | 72.46±1.35 |
| Back-fat thickness (mm) | | 11.40±2.07$^{d}$ | 17.81±1.25$^{c}$ | 21.79±1.25$^{b}$ | 27.60±1.38$^{a}$ | 20.98±4.31 |
| Hunter | L* | 39.01±2.49 | 38.17±3.20 | 37.79±3.38 | 38.68±4.56 | 38.14±3.80 |
| | a* | 4.26±0.91 | 4.74±1.65 | 4.57±1.73 | 4.98±1.63 | 4.68±1.65 |
| | b* | 5.25±0.86$^{b}$ | 6.23±1.67$^{a}$ | 5.93±1.22$^{a}$ | 6.27±1.05$^{a}$ | 6.04±1.21 |
| pH | | 5.63±0.16$^{ab}$ | 5.58±0.13$^{ab}$ | 5.61±0.12$^{ab}$ | 5.66±0.16$^{a}$ | 5.61±0.13 |
| Visual color (1-7) | | 3.40±0.52 | 3.65±1.04 | 3.61±0.94 | 3.60±1.22 | 3.61±1.00 |
| Marbling scores (1-5) | | 2.60±0.84$^{b}$ | 3.27±1.47$^{ab}$ | 3.39±1.30$^{a}$ | 3.67±1.10$^{a}$ | 3.36±1.31 |
| Meat quality grades ($1^{+}$-2) | | 2.60±0.52$^{c}$ | 2.04±0.71$^{b}$ | 1.71±0.51$^{ab}$ | 1.53±0.51$^{a}$ | 1.83±0.64 |

All values are the mean±standard deviation.
$^{a-d}$Values with the different superscripts are significantly different ($p$<0.05).

and concluded that pH is similar among pigs in the same growth phase.

The average visual color against the standard plate was 3.61 and the groups depending on visual color were no significant differences among the groups. The low back-fat thickness group (<15 mm group) exhibited light color (3.40).

The average marbling score was 3.36 and the groups of marbling score were significant differences noted among the groups ($p$<0.05). Marbling score was reported to be the highest for the ≥25 mm group (3.67) and the lowest for the <15 mm group (2.60), indicating that marbling increased with an increase in the back-fat thickness. This result contradicted the study by Moon *et al.* (2003), which reported a small association between increased weight at marketing and fat production. However, in their study with Korean native pigs, Cho *et al.* (2007a) showed that the production of fat, skin, bone, and perirenal fat tended to increase with an increase in weight, regardless of sex. In addition, our findings were also similar to the results of Kim and Lim (2006) and Kim and Kim (2009), where intramuscular fat content increased with increase in the back-fat thickness and age at marketing in finishing pigs.

The average meat quality score was 1.83 and the groups according to meat quality score were significant differences among the groups ($p$<0.05). The group with highest back-fat thickness (≥25 mm) showed a low (good) quality score (1.53 points), while that with the lowest back-fat thickness (<15 mm) showed a high (poor) quality score (2.60), indicating better meat quality with increase in back-fat thickness. These results were similar to those observed by Kim (2012), where finishing pigs with 15-19 mm back-fat showed a higher proportion of better quality grades (grades 1+ and 1) and those with <15 mm back-fat showed a higher proportion of a poor quality grade (grade 2). The same grading criteria used for crossbreeds and Korean native pigs may have contributed to such results.

## Correlation among carcass traits

Table 4 showed the estimated correlations among the carcass traits of Korean native pigs. Carcass weight showed a strong positive correlation with meat quality grade (r=0.739) and significant moderate correlation with carcass yield (r=0.262), back-fat thickness (r=0.346), and marbling score (r=0.176). A moderate positive correlation was observed between carcass yield and back-fat thickness (r=0.223). These results showed similar trend comparing with those reported by Kim and Kim (2009), where carcass weight was positively correlated with back-fat thickness as well as carcass grade in finishing pigs.

Back-fat thickness displayed a strong positive correlation with meat quality grade (r=0.444), as reported by Kim and Kim (2009), and a low positive correlation with visual color (r=0.192) as well as marbling score (r=0.167).

Meat quality grade was moderately correlated with marbling score (r=0.360) but not with other carcass traits. A negative correlation was observed between the Hunter L* value and a* value (r=-0.237), pH (r=-0.324), as well as visual color (r=-0.587). However, a strong positive correlation was seen between the L* and b* values (r=0.529). Furthermore, the a* value exhibited a moderate positive correlation with the b* value (r=0.410), pH (r=0.234), visual color (r=0.375), and marbling score (r=0.194). The b* value showed a low negative correlation with visual color (r=-0.160) and a low positive correlation with marbling score (r=0.190).

In addition, pH was estimated to show moderate positive correlation with visual color (r=0.360). These results were in line with those reported by Kim and Kim (2009), where a small correlation between visual color and mar-

**Table 4. Correlation coefficients between carcass characteristics of Korean Native Pigs**

| Items | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Carcass weight ($x_1$) | 1 | 0.262** | 0.346** | 0.739*** | 0.031 | -0.099 | -0.073 | -0.001 | 0.067 | 0.176* |
| Carcass % ($x_2$) | | 1 | 0.223** | 0.009 | 0.067 | -0.084 | -0.020 | -0.052 | 0.016 | -0.072 |
| Back-fat ($x_3$) | | | 1 | 0.444** | 0.048 | 0.052 | 0.048 | 0.192* | 0.028 | 0.167* |
| Quality grades ($x_4$) | | | | 1 | 0.029 | -0.009 | 0.033 | 0.047 | 0.085 | 0.360** |
| Hunter L* ($x_5$) | | | | | 1 | -0.237** | 0.529** | -0.324** | -0.587** | 0.147 |
| Hunter a* ($x_6$) | | | | | | 1 | 0.410** | 0.234** | 0.375** | 0.194* |
| Hunter b* ($x_7$) | | | | | | | 1 | -0.135 | -0.160 | 0.190* |
| pH ($x_8$) | | | | | | | | 1 | 0.360** | -0.021 |
| Meat color ($x_9$) | | | | | | | | | 1 | 0.117 |
| Marbling scores ($x_{10}$) | | | | | | | | | | 1 |

*$p$<0.05, **$p$<0.01, ***$p$<0.001.

bling score was recorded. Meat color showed a low positive correlation with marbling scores (r=0.117).

## Conclusion

Our study analyzed the carcass properties of Korean native pigs in relation to carcass weight and back-fat thickness for the production and distribution of high quality pork meat. Compared to crossbreeds, Korean native pigs have lower carcass weight but thicker back-fat, which prevents them from receiving good carcass grades. Therefore, there are required to manage the breeding through selection of excellent native species for increasing their carcass weight and enhance meat quality. Moreover, Korean native pigs which have gained much consumer preference, owing to their relatively bright red color, appropriate texture, and flavor will be a good meat resource.

## Reference


1. Cameron, N. D., Warriss, P. D., Porter, S. J., and Enser. M. B. (1990) Comparison of Duroc and British landrace pigs for meat and eating quality. *Meat Sci.* **27,** 227-237.
2. Cho, S. H., Park, B. Y., Kim, J. H., Kim, M. J., Seong, P. N., Kim, Y. J., Kim, D. H., and Ahn, C. N. (2007a) Carcass yields and meat quality by live weight of Korean native black pigs. *Korean J. Anim. Sci. Technol.* **49**, 523-530.
3. Cho, S. H., Seong, P. N., Kim, J. H., Park, B. Y., Kwon, O. S., Hah, K. H., Kim, D. H., and Ahn, C. N. (2007b) Comparison of meat quality, nutritional, and sensory properties of Korean native pigs by gender. *Korean J. Food Sci. Ani. Resour.* **27**, 475-481.
4. Choi, Y. I., Kim, Y. T., Lee, C. L., and Han, I. K. (2000) Carcass and pork quality characteristics by sex and marketing day. *J. Anim. Sci. Technol.* **42**, 933-940.
5. Choi, Y. S. (2004) Studies on the pork quality of Korean native black pigs and its improvement through dietary manipulation. Ph. D. thesis, Kangwon National Univ., Chuncheon, Korea, pp. 1-169.
6. Choi, Y. S., Park, B. Y., Lee, J. M., and Lee, S. K. (2005) Comparison of carcass and meat quality characteristics between Korean native black pigs and commercial crossbred pigs. *Korean J. Food Sci. Ani. Resour.* **25**, 322-327.
7. Enfalt, A. C., Lundstrom, K., Hansson, I., Lundeheim, N., and Nystrom, P. E. (1997) Effects of outdoor rearing and sire breed (Duroc or Yorkshire) on carcass composition and sensory and technological meat quality. *Meat Sci.* **45**, 1-15.
8. Hah, K. H., Jin, S. K., Kim, I. S., Song, Y. M., Lee, J. R., and Chung, K. Y. (2005) Pork quality characteristics by different backfat thickness. *Korean J. Food Sci. Ani. Resour.* **25**, 391-396.
9. Jeremiah, L. E., Gibson, J. P., Gibson, L. L., Ball, R. O., Aker, C., and Fortin, A. (1999) The influence of breed, gender, and PSS (halothane) genotype on meat quality, cooking loss, and palatability of pork. *Food Res. Int.* **32**, 59-71.
10. Jin, S. K., Kim, C. W., Song, Y. M., Jang, W. H., Kim, Y. B., Yeo, J. S., Kim, J. W., and Kang, K. H. (2001) Physicochemical characteristics of longissimus muscle between the Korean native pig and landrace. *Korean J. Food Sci. An.* **21**, 142-148.
11. Jin, S. K., Kim, I. S., Hur, S. J., Hah, K. H., and Kim, B. W. (2005) Physico-chemical characteristics with market weight in korean native and landrace crossbred pigs. *Korean J. Intl. Agri.* **17**, 182-187.
12. Jin, S. K., Kim, I. S., Song, Y. M., Hur, S. J., Hah, K. H., Kim, H. Y., Lyou, H. J., Ha, J. H., and Kim, B. W. (2004) Physicochemical characteristics of crossbred pigs with carcass grade. *Korean J. Food Sci. Ani. Resour.* **24**, 246-252.
13. Kim, G. W. (2012) Analysis of carcass quality grades according to gender, backfat thickness and carcass weight in pigs. *Korean J. Anim. Sci. Technol.* **54**, 29-33.
14. Kim, G. W. and Kim, S. E. (2009) Effect of mating system, carcass grade and age at marketing on carcass characteristics of pigs. *Korean J. Anim. Sci. Technol.* **51**, 69-74.
15. Kim, G. W. and Lim, B. S. (2006) Carcass grade and characteristics by carcass weight and backfat thickness of pigs. *Korean J. Food Sci. Ani. Resour.* **26**, 183-188.
16. Kim, H. S., Yang, H. S., Lee, J. I., Joo, S. T., Jeon, J. T., and Lee, J. G. (2007) Effects of the mating system on retail cut yield and meat quality in commercial pigs. *Korean J. Anim. Sci. Technol.* **49**, 379-386.
17. Kim, I. S., Jin, S. K., Kim, C. W., Song, Y. M., Cho, K. K., and Chung, K. H. (2008) Animal products and processing: The effects of pig breeds on proximate, physicochemical, cholesterol, amino acid, fatty acid and sensory properties of loins. *Korean J. Anim. Sci.* **50**, 121-132.
18. Larzul, C., Lefaucheur, L., Ecolan, P., Gogue, J., Talmant, A., Sellier, P., Le Roy, P., and Monin, G. (1997) Phenotypic and genetic parameters for longissimus muscle fiver characteristics in relation to growth, carcass, and meat quality traits in large white pigs. *J. Anim. Sci.* **75**, 126.
19. Martens, H. (1998) Physiologie der muskulature und das MHS-Gen schweines: Zur diskussion um eine eliminierung des mutierten ryanodin rezeptors aus der deutschen schweinezucht. *Arch. Tierzucht Dummersdorf.* **41**, 179-192.
20. Moon, S. S., Mullen, A. M., Troy, D. J., Yang, H. S., Joo, S. T., and Park, G. B. (2003) Effect of pig slaughter weight on pork quality. *Korean J. Food Sci. Ani. Resour.* **23**, 315-320.
21. Oh, H. S., Kim, H. Y., Yang, H. S., Lee, J. I., Joo, Y. K., and Kim, C. U. (2008) Comparison of meat quality characteristics between crossbreeds. *Korean J. Food Sci. Ani. Resour.* **28**, 171-180.
22. Oliver, M. A., Gispert, M., and Diestre, A. (1993) The effects of breed and halothane sensitivity on pig meat quality. *Meat Sci.* **35**, 105-112.
23. Park, J. C., Kim, Y. K., Jung, H. J., Park, B. Y., Lee, J. I., and Moon, H. K. (2005) Comparison of meat quality and physocochemical characteristics of pork between Korean native

black pigs and Landrace by market weight. *Korean J. Anim. Sci.* **47**, 91-98.
24. Park, M. J., Ha, D. M., Shin, H. W., Lee, S. H., Kim, W. K., Ha, S. H., Yang, H. S., Jeong, J. Y., Joo, S. T., and Lee, C. Y. (2007) Growth efficiency, carcass quality characteristics and profitability of 'High'-Market weight pigs. *Korean J. Anim. Sci. Technol.* **49**, 459-470.
25. Park, M. J., Jeong, J. Y., Ha, D. M., Han, J. C., Sim, T. G., Park, B. C., Park, G. B., Joo, S. T., and Lee, C. Y. (2009) Effects of dietary energy level and slaughter weight on growth performance and grades and quality traits of the carcass in finishing pigs. *Korean J. Anim. Sci. Technol.* **51**, 143-154.
26. Sather, A. P., Jones, D. M., Tong, A. K. W. and Murray, A. C. (1991) Halothane genotype by weight interactions on pig meat quality. *Canadian J. Anim. Sci.* **71**, 645-658.
27. Warriss, P. D., Brown, S. N., Edwards, J. E. and Knowles, T. G. (1995) Effect of lairage time on levels of stress meat quality inpigs. Proceedings of EU-Seminar: New information on welfareand meat quality of pigs related to holding, transport and lairageconditions, Mariensee, Germany. pp. 163-170.