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., 2004; Kim, 2012; Larzul et al., 1997).

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., 2007a; Martens, 1998; Oh et al., 2008; Warris et al., 1995).
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).

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
Carcass Properties of Korean Native Pigs

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 \((p<0.05)\). 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.

Table 2. Carcass characteristics by carcass weight groups

| Traits                  | < 70 (N=40) | 70-74 (N=64) | 75-79 (N=48) | ≥ 80 (N=18) | Average±S.D. |
|-------------------------|-------------|--------------|--------------|-------------|--------------|
| Carcass weight (kg)     | 66.00±3.17  | 72.25±1.26   | 76.75±1.35   | 81.63±1.46  | 72.94±5.17  |
| Carcass %               | 71.51±1.49  | 73.41±0.98   | 71.83±0.86   | 72.97±0.60  | 72.46±1.35  |
| Back-fat thickness (mm) | 18.75±4.54  | 21.34±4.62   | 21.29±2.94   | 24.13±3.40  | 20.98±4.31  |
| L*                     | 38.83±3.02  | 38.80±4.31   | 37.72±2.98   | 38.19±5.40  | 38.14±3.80  |
| a*                     | 4.68±1.31   | 4.76±2.00    | 4.72±1.60    | 4.26±0.81   | 4.68±1.65   |
| 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   | 3.59±1.12ab  | 3.92±0.82ab  | 3.50±1.50ab | 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±0.48d  | 2.13±0.33c   | 1.29±0.46b   | 1.00±0.00a  | 1.83±0.64   |

All values are the mean±standard deviation.

a-cValues 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.

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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 crossbreds (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 different back-fat thickness groups \( (p<0.05) \). The mean carcass weights of the \( \geq \)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 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 \( \geq \)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 \( \geq \)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 |
|-----------------------------------------------|
| Back-fat thickness (mm) | < 15 (N=12) | 15-19 (N=52) | 20-24 (N=76) | \( \geq \) 25 (N=30) | Average+ S.D. |
|-------------------------|------------|-------------|-------------|----------------|--------------|
| Carcass weight (kg)     | 69.20±4.69\textsuperscript{a} | 72.19±3.10\textsuperscript{a} | 72.76±5.32\textsuperscript{a} | 75.93±3.65\textsuperscript{a} | 72.94±3.17\textsuperscript{a} |
| Carcass %               | 72.07±0.55\textsuperscript{b} | 72.20±1.35\textsuperscript{b} | 72.48±1.52\textsuperscript{b} | 73.03±0.83\textsuperscript{b} | 72.46±1.35\textsuperscript{b} |
| Back-fat thickness (mm) | 11.40±2.07\textsuperscript{a} | 17.81±1.25\textsuperscript{a} | 21.79±1.25\textsuperscript{a} | 27.60±1.38\textsuperscript{a} | 20.98±4.31\textsuperscript{a} |
| Hunter L*               | 39.01±2.49\textsuperscript{b} | 38.17±3.20\textsuperscript{b} | 37.79±3.38\textsuperscript{b} | 38.68±4.56\textsuperscript{b} | 38.14±3.80\textsuperscript{b} |
| Hunter a*               | 4.26±0.91\textsuperscript{a} | 4.74±1.65\textsuperscript{a} | 4.57±1.73\textsuperscript{a} | 4.98±1.63\textsuperscript{a} | 4.68±1.65\textsuperscript{a} |
| Hunter b*               | 5.25±0.86\textsuperscript{b} | 6.23±1.67\textsuperscript{b} | 5.93±1.22\textsuperscript{b} | 6.27±1.05\textsuperscript{b} | 6.04±1.21\textsuperscript{b} |
| pH                      | 5.63±0.16\textsuperscript{a} | 5.58±0.13\textsuperscript{a} | 5.61±0.12\textsuperscript{a} | 5.66±0.16\textsuperscript{a} | 5.61±0.13\textsuperscript{a} |
| Visual color (1-7)      | 3.40±0.52\textsuperscript{a} | 3.65±1.04\textsuperscript{a} | 3.61±0.94\textsuperscript{a} | 3.60±1.22\textsuperscript{a} | 3.61±1.00\textsuperscript{a} |
| Marbling scores (1-5)   | 2.60±0.84\textsuperscript{a} | 3.27±1.47\textsuperscript{a} | 3.39±1.30\textsuperscript{a} | 3.67±1.10\textsuperscript{a} | 3.36±1.31\textsuperscript{a} |
| Meat quality grades (1-2)| 2.60±0.52\textsuperscript{a} | 2.04±0.71\textsuperscript{b} | 1.71±0.51\textsuperscript{b} | 1.53±0.51\textsuperscript{b} | 1.83±0.64\textsuperscript{b} |

All values are the mean±standard deviation. \( ^{a-b} \)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. 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                  | x1  | x2  | x3  | x4  | x5  | x6  | x7  | x8  | x9  | x10 |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 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 | 0.016 | -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** |
| 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   | 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.

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