

Physicochemical Characteristics and Fatty Acid Composition of the Meat from Korean Native Black Pig with Different Slaughter Weight

Il-Suk Kim¹, Sang-Keun Jin¹, Cheorun Jo², Mooha Lee³, and Aera Jang^{4†}

¹Department of Animal Resources Technology, Jinju National University, Jinju 660-758, Korea

²Department of Animal Science and Biotechnology, Chungnam National University, Daejeon 305-764, Korea

³Department of Food and Animal Biotechnology, Seoul National University, Seoul 151-921, Korea

⁴Quality Control and Utilization of Animal Products Division, National Institute of Animal Science, Suwon 441-706, Korea

Abstract

The Korean native black pig (KNP) have several desirable meat qualities, which are highly demanded by Koreans in spite of its slow growth rate, low feed efficiency, and small litter size. The aim of this study was to evaluate meat quality and fatty acid composition of KNP at different slaughter weight in order to provide information to industry. Ninety female KNP of the same age (220 days) were divided into three groups by live body weights (30 pigs per each group); live weight of 50~59 kg (T1), 60~69 kg (T2) and 70~80 kg (T3), respectively. After slaughtering the *longissimus dorsi* muscle (LD) and backfat from each group were obtained after 24 hr chilling. Crude protein content and shear force of LD from T3 was higher than that from T1 and pH of LD was significantly lower in that from T1 than from T2 and T3. Color measurement indicated that LD of T2 group had a higher L*-value and lower a*-value than those of T1 and T3. Slaughter weight of KNP generally did not affect the fatty acid composition of LD and backfat but the content of oleic acid (C18:1) of T2 in LD was significantly higher than those of T1 and T3. The results may provide basic information to industry to promote the production and processing of KNP, and assist in meeting the Korean consumer's demand.

Key words: Korean native black pig, slaughter weight, meat quality, fatty acid composition

INTRODUCTION

The Korean native black pig (KNP) is the typical breed which was widely raised on farms in Korea until the 1970's. There was a significant decline in their numbers thereafter due to the introduction of improved breeds for both growth and lean meat production (1), since KNP showed a relatively slow growth rate, low feed efficiency, thick backfat, and small litter size (2). In contrast, KNP is well known for its strong disease tolerance (3).

The progress in the production of lean meat during the last decades has largely taken place at the expense of meat quality, causing serious problems in the tenderness and the water holding capacity (WHC) of meat (4). However, KNP has firm and white fat and more reddish meat color than commercial pig such as Landrace, while the reddish meat color combined with high intramuscular fat content is one of the meats attributes demanded by Korean consumers (5).

There are some important factors controlling pork meat quality such as WHC, color, tenderness, and post-

mortem pH decline (6). WHC has been studied extensively because of its enormous economic importance and it influences the sensory properties of the product such as juiciness, texture, and flavor (7). Numerous and complex factors such as genotype, different stunning methods, aging, chilling rate, and protein oxidation may contribute to the variability in WHC of meat (8). Color of the fresh meat is one of the most important factors to consumers, determined by concentration of myoglobin and heme pigments (9).

Pigs are generally slaughtered at a constant body weight to maintain uniformity of pork products and maximize profits (10). Correa et al. (11) reported that there was a significant increase in hot carcass weight and dressing percentage as slaughter weight increased. However, no significant difference was found in lean, fat, and bone proportions. Pork quality was rated higher in terms of juiciness, flavor and tenderness at heavier slaughter weight (12), which would be attributable to differences in intramuscular fat composition (13). However, at slaughter many different weights of KNP are produced because of its slow growth rate and it be-

†Corresponding author. E-mail: aerajang@rda.go.kr
Phone: +82-31-290-1685, Fax: +82-31-290-1697

comes a major problem of the Korean native pig industry. In addition, little information on the effect of different market weights on physicochemical traits of KNP meat, which is enable to encourage consumer's acceptance. Therefore, the aim of this study was to evaluate meat quality and fatty acid composition of KNP at different slaughter weights.

MATERIALS AND METHODS

Animal and sampling procedure

Ninety female Korean native black pigs (KNP) were raised for 220 days in a commercial farm (Songhak farm, Pohang, Korea) under the auspices of the National Livestock Research Institute (NLRI) program in Korea. All animals were fed commercial diets and water was offered *ad libitum*. On 220 d, total 60 KNPs were grouped by live weight as 50~59 kg (T1), 60~69 kg (T2), and 70~80 kg (T3). They were transferred to a commercial abattoir by ordinary commercial trucking system. After slaughter the carcasses were placed in a cold room (1°C) for 24 hrs and the loin (*longissimus dorsi*, LD) and backfat was removed and trimmed from both sides of 20 carcasses and analyzed for physicochemical and fatty acid composition.

Proximate composition analysis and pH

Contents of moisture, crude protein, crude fat, and crude ash of loin of KNP was determined according to the AOAC method (14). For pH measurement, 10 g of trimmed LD was homogenized at 13,500 rpm for 10 min with 90 mL of distilled water and measured by a pH meter (Orion 230A, Boston, MA, USA).

Color

Meat color values, CIE L*, a*, and b*-values, were determined five times on a freshly cut surface of meat after 30 min of blooming at 1°C using a Minolta Chromameter (CR301, Minolta, Osaka, Japan). The chromameter was calibrated against standard plate (L*=89.2, a*=0.921, b*=0.783) before use.

Water holding capacity (WHC)

One gram of minced LD was placed on a plate with small holes in 2 mL plastic tube. This tube centrifuged at 920×g for 10 min. The released water contents was subtracted from LD weight and calculated as a percentage of the initial weight.

Cooking loss

For cooking loss, 200 g of LD was placed in 220°C electric oven until an internal temperature became 70°C. The cooked LD was cooled at room temperature and the meat weight expressed as a percentage of the initial

weight.

Shear force

The LD was cut into a cylinder shape (17 mm width × 2 cm length) and sheared once using an Instron 3343 (US/MX50, A&D Co., Norwood, MA, USA) equipped with a Warner Bratzler shearing device. Samples were placed on sample holder and measured by cross head speed at 200 mm/min.

Fatty acid composition

The lipids from LD were extracted using the method described by Folch et al. (15) and fatty acid in the sample was methylated by 4% methanolic H₂SO₄. The fatty acid methylesters were separated on a gas chromatograph (HP 6890, Hewlett Packard, Co., Wilmington, DE, USA) equipped with flame ionization detector. A split inlet (split ratio, 10:1) was used to inject samples into a HP-5-MS fused silica capillary column (30 m×0.25 μm) and ramped oven temperature was used (160°C for 5 min and increased to 240°C at 2°C/min). Inlet and detector temperature was 280°C. Helium was the carrier gas at a constant flow rate at 1.0 mL/min.

Statistical analysis

All data were analyzed by SAS software (16). A general linear model (GLM) procedure was performed and mean values and standard error were reported. Duncan's multiple range tests were used to compare the mean values and p<0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Proximate compositions of LD of KNPs with different slaughter weights are shown in Table 1. No significant difference was found in the contents of moisture, crude fat, and crude ash, which were in a range of 70.35~71.78, 4.74~6.07, and 1.02~1.06%, respectively. However, crude protein of T3, the heaviest slaughter weight group, was significantly higher than that of T1 and T2 (p<0.05). Correa et al. (11) reported that muscle protein increased with increased slaughter weight from 107 to 115 kg.

Table 1. Proximate composition (%) of *longissimus dorsi* obtained from Korean native black pigs at different slaughter weight

| Group ¹⁾ | Moisture | Crude protein | Crude fat | Crude ash |
|---------------------|------------|--------------------------|-----------|-----------|
| T1 | 70.61±2.19 | 21.78±0.54 ^{ab} | 5.71±1.88 | 1.02±0.07 |
| T2 | 70.35±1.83 | 21.41±1.10 ^b | 6.07±2.65 | 1.05±0.10 |
| T3 | 71.78±2.94 | 22.26±0.32 ^a | 4.74±1.34 | 1.06±0.04 |

^{a,b}Means with different superscripts in the same column are significantly different at p<0.05.

¹⁾T1, body weight at slaughter ranged 50~59 kg; T2, 60~69 kg; T3, 70~80 kg.

Table 2. pH, cooking loss, water holding capacity (WHC) of *longissimus dorsi* obtained from Korean native black pigs at different slaughter weights

| Group ¹⁾ | pH | Cooking loss (%) | WHC (%) | Shear force (g/cm ²) |
|---------------------|--------------------------|------------------|--------------|----------------------------------|
| T1 | 5.06 ± 0.05 ^b | 35.65 ± 3.84 | 71.15 ± 5.97 | 2,918 ± 882 ^b |
| T2 | 5.14 ± 0.09 ^a | 35.41 ± 2.79 | 72.76 ± 7.35 | 3,594 ± 1306 ^{ab} |
| T3 | 5.13 ± 0.02 ^a | 36.10 ± 2.56 | 70.04 ± 1.93 | 4,357 ± 1808 ^a |

^{a,b}Means with different superscripts in the same column are significantly different at $p < 0.05$.

¹⁾T1~T3: Refer to Table 1.

However, Park et al. (17) pointed out that the lean meat yield of KNP (70~90 kg live weight) was higher than that of Landrace pig (110 kg live weight).

Physicochemical characteristics including pH, cooking loss, water holding capacity (WHC), and shear force of LD of KNP are shown in Table 2. The pH values of KNPs with slaughter weights ranging from 50~59 kg (T1), and were significantly lower than those of KNPs with heavier slaughter weights (T2 and T3, $p < 0.05$) even though all the pH values were lower than those of commercial breeds. However, this pH difference did not influence cooking loss and WHC (Table 2). Kauffman et al. (18) and McKeith et al. (19) reported that native pigs were characterized by long rearing periods, low body weight, thin backfat, and traits similar to PSE (pale, soft, exudative) meat. Cooking loss was higher in LD of high weight KNPs, while no significant difference was found. Generally, WHC is significantly influenced by lactic acid production and pH decline (20). At pH 5, the isoelectric point (pI) of myosin and actomyosin proteins, the lowest WHC was realized, and high pH resulted in low cooking loss and high WHC (20). On the other hand, Eikelenboom and Nanni Costa (21) suggested that cooking loss has no relationship with sarcomere length, pH, and color. The variability in shear force was high in the present study but T3 exhibited a higher shear force value than T1 ($p < 0.05$). This result suggested that when KNPs have high market weights, tenderness is adversely affected, which is in agreement with the report of Park et al. (17), who found that the shear force of LD from 70 kg slaughter weight KNP (3.17 kg/cm²) was lower than that of 90 kg slaughter weight KNP (4.40 kg/cm²). Furthermore, they also suggested that KNP with 70 kg slaughter weight showed significantly greater cooking loss when compared with that with 90 kg slaughter weight. Jin et al. (2) reported that lower shear force of LD obtained from lower slaughter weight KNP may due to its slow growth rate and underdeveloped muscle fiber.

Meat color is influenced by many different factors such as pH, atmosphere, and WHC. Color of LDs and

Table 3. CIE* color values of the *longissimus dorsi* muscle and backfat obtained from Korean native black pigs at different slaughter weight

| Tissues | Group ¹⁾ | L* | a* | b* |
|---------------------------------|---------------------|----------------------------|---------------------------|--------------------------|
| <i>Longissimus dorsi</i> muscle | T1 | 42.41 ± 2.88 ^b | 10.92 ± 1.56 ^a | 4.02 ± 0.62 |
| | T2 | 44.90 ± 3.02 ^a | 8.14 ± 2.05 ^b | 3.34 ± 1.43 |
| | T3 | 41.93 ± 2.84 ^b | 9.83 ± 1.23 ^a | 3.32 ± 0.81 |
| Backfat | T1 | 70.85 ± 2.44 ^a | 2.52 ± 0.32 ^b | 2.27 ± 0.29 ^b |
| | T2 | 71.40 ± 2.18 ^a | 1.94 ± 0.21 ^b | 2.74 ± 0.55 ^a |
| | T3 | 63.67 ± 13.58 ^b | 4.62 ± 4.54 ^a | 3.01 ± 0.90 ^a |

^{a,b}Means with different superscripts in the same column are significantly different at $p < 0.05$.

¹⁾T1~T3: Refer to Table 1.

backfat obtained from KNPs at different market weights are shown in Table 3. KNP in T2 showed higher L*-values than T1 and T3, which ranged 41.93~44.90. van Laack et al. (22) reported that pork meat can be grouped as PSE (L*-value is more than 58), normal meat (L*-value is between 52 and 58), and DFD (Dark, Firm, Dry, L*-value is less than 52) by L*-value. Redness (a*-value) of LD was higher in T1 and T3 ($p < 0.05$) than T2, and result in a lower L*-value. No differences was found in b*-values. This result suggested that LD of KNP at high and low slaughter weight resulted in a darker and redder color than LD of middle slaughter weight KNP. L* and a* values of backfat of higher slaughter weights (T3) were significantly lower than those of T1 and T2 ($p < 0.05$). Also, b* value of T1 was lower than that of T2 and T3 ($p < 0.05$). This result indicated that a slaughter weight can influence the backfat color of KNP and that lower slaughter weight KNP produces a lighter colored fat.

Fatty acid composition of LD and backfat and its ratio from KNP at different slaughter weights are shown at Figs. 1~4. There were no significant differences in fatty acid composition among the treatments except for the amount of C18:1, oleic acid, in LD. Fatty acid composition can, however, be changed by different diet, genetics, sex, and fatness. The total fatty acid content of muscle (i.e. neutral lipid plus phospholipids fatty acid), termed marbling fat, has long been recognized as a factor in organoleptic quality, especially juiciness and tenderness (23). In the present study, significantly higher level of C18:1 was found in T2 compare to T1 and T3 ($p < 0.05$). C18:1 and C18:2 are the predominant fatty acids in pork, causing a higher ratio of unsaturated fatty acid to saturated fatty acid. As for health benefits, a high C18:1 content and low P:S ratio are important in reducing the risk of cardiovascular diseases (24). However, no difference was found in the amount of saturated fatty acids (SFA), unsaturated fatty acids (UFA), essential fatty

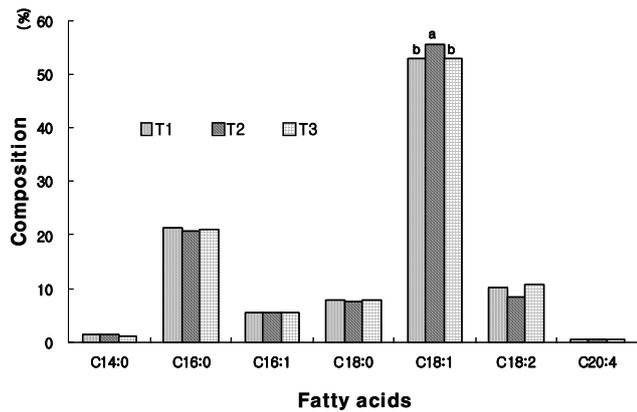


Fig. 1. Fatty acid composition of *longissimus dorsi* obtained from Korean native black pigs at different slaughter weights. ^{a,b}Means with different superscripts in the same column are significantly different at $p < 0.05$. T1~T3: Refer to Table 1.

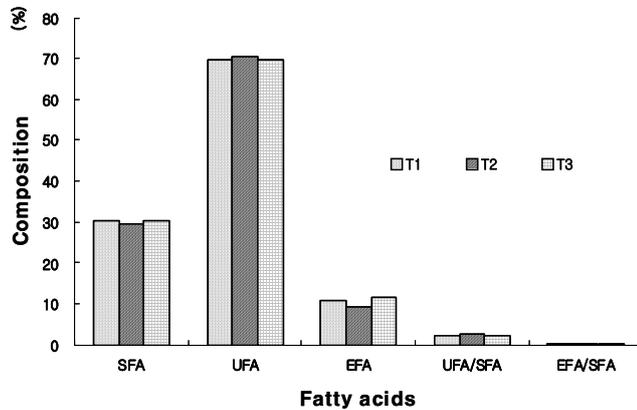


Fig. 2. Fatty acid profile of *longissimus dorsi* obtained from Korean native black pigs at different slaughter weights. T1~T3: Refer to Table 1. SFA: saturated fatty acid, UFA: unsaturated fatty acid, EFA: essential fatty acid.

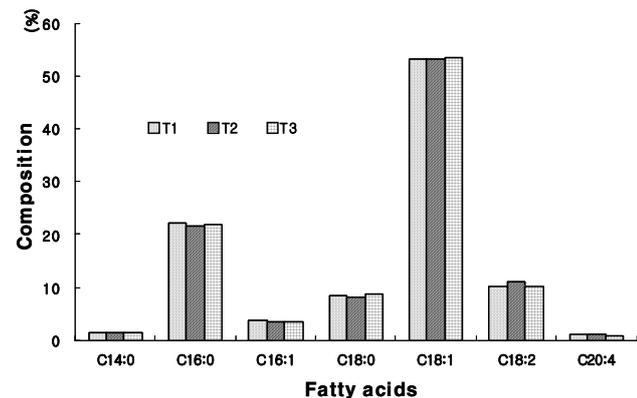


Fig. 3. Fatty acid composition of backfat obtained from Korean native black pigs at different slaughter weights. T1~T3: Refer to Table 1.

acids (EFA), the ratio of UFA/SFA, and EFA/SFA between LD and backfat. Wood et al. (23) suggested that some meats naturally have a ratio of around 0.1 of

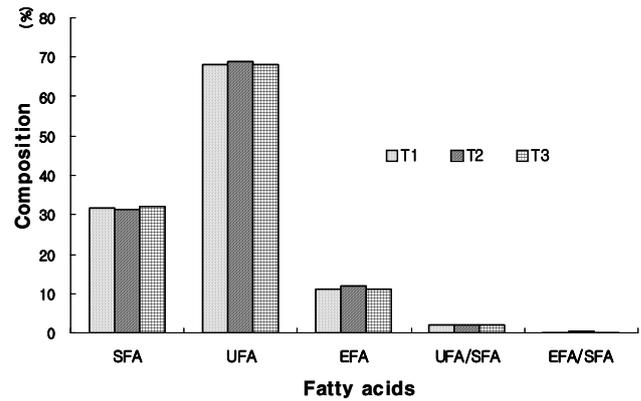


Fig. 4. Fatty acid profile of backfat obtained from Korean native black pigs at different slaughter weights.

^{a,b}Means with different superscripts in the same column significantly differ at $p < 0.05$. T1~T3: Refer to Table 1. SFA: saturated fatty acid, UFA: unsaturated fatty acid, EFA: essential fatty acid.

UFA/SFA and the Department of Health in UK recommended that intake ratio of UFA/SFA should be increased to above 0.4. From the calculation, a UFA/SFA ratio of LD from T1, T2, and T3 was 0.54, 0.47, and 0.57, respectively, and those values indicated that KNP met the recommended ratio.

Fatty acids are involved in various technological aspects of meat quality (23). Since they have very different melting points, variation in fatty acid composition has an important effect on firmness or softness of the fat in meat, not only the subcutaneous and intermuscular (carcass fats) but also the intramuscular (marbling) fat. Generally, solidified fat with a high melting point is whiter in color than liquid fat with low melting points and therefore fat color is affected by the fatty acid composition. The UFA/SFA ratio was ranged from 0.35 ~ 0.38 in backfat and no differences were found among treatments. This result suggested that C18:1 from LD of middle weight KNP was higher and composition of the other fatty acids was not affected by slaughter weight.

CONCLUSIONS

The present study demonstrated that different slaughter weights may influence meat quality of Korean native black pig, including: shear force, color, and fatty acid composition of C18:1. Although KNP have a slow growth rate, thick backfat, and dark meat color, there is currently great demand for KNP because of its high eating quality and acceptability by consumers. Therefore, the results of the present study may provide basic information to industry, and further study for genetic characteristics in terms of economical aspects is needed.

REFERENCES

1. Park BY, Kim NK, Lee CS, Hwang IH. 2007. Effect of fiber type on postmortem proteolysis in longissimus muscle of Landrace and Korean native black pigs. *Meat Sci* 77: 482-491.
2. Jin SK, Kim CW, Song YM, Jang WH, Kim YB, Yeo JS, Kim JW, Kang KH. 2001. Physicochemical characteristics of longissimus muscle between the Korean native pig and landrace. *Kor J Food Sci Ani Resour* 21: 142-148.
3. Rural Development Administration (RDA). 2001. Korean native black pig (standard farm textbook-121). Korea. p 1-22
4. van de Wiel DFM, Zhang WL. 2007. Identification of pork quality parameters by proteomics. *Meat Sci* 77: 46-54.
5. Hwang IH, Park BY, Cho SH, Kim JH, Lee JM. 2004. Identification of muscle proteins related to objective meat quality in Korean native black pig. *Asian Australas J Anim Sci* 17: 1599-1607.
6. van der Wal PG, Engel B, Hulsegge B. 1997. Causes for variation in pork quality. *Meat Sci* 46: 319-327.
7. Trout G. 1988. Techniques for measuring water-binding capacity in muscle foods- a review of methodology. *Meat Sci* 23: 235-252.
8. Zhang WG, Lonergan SM, Gardner MA, Huff-Lonergan E. 2006. Contribution of postmortem changes of integrin, desmin and μ -calpain to variation in water holding capacity of pork. *Meat Sci* 74: 578-585.
9. Greene BE, Hsin I, Zipser MW. 1971. Retardation of oxidative color changes in raw ground beef. *J Food Sci* 36: 940-942.
10. Federick BR, van Heugten E, See MT. 2006. Effects of pig age at market weight and magnesium supplementation through drinking water on pork quality. *J Ani Sci* 84: 1512-1519.
11. Correa JA, Faucitano L, Laforest JP, Rivest J, Marcoux M, Garipey C. 2006. Effect of slaughter weight on carcass composition and meat quality in pigs of two different growth rates. *Meat Sci* 72: 97-99.
12. Piao JR, Tian JZ, Kim BG, Choi YI, Kim YY, Han IK. 2004. Effects of sex and market weight on growth performance, carcass characteristics and pork quality of market hogs. *Asian Australas J Anim Sci* 10: 1452-1458.
13. Hugo A, Osthoff G, Jooste PJ. 1999. Effect of slaughter weight on the intramuscular fat compositions on pigs. Proceedings of the 45th International Congress of Meat Science and Technology, Yokohama, Japan. p 496-497.
14. AOAC. 1990. Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists, Washington, DC.
15. Folch L, Lees M, Sloane-Stanley SHA. 1957. A simple method for the isolation and purification of total lipids from animal tissues. *J Biol Chem* 226: 497-507.
16. SAS. 2002. SAS[®] User's guide: Statistics. Version 9.01 ed. SAS Institute Inc., Cary, NC, USA.
17. Park JC, Kim YH, Jung HJ, Park BY, Lee JI, Moon HK. 2005. Comparison of meat quality and physicochemical characteristics of pork between Korean native black pigs (KNBP) and landrace by market weight. *Kor J Anim Sci Technol* 47: 91-98.
18. Kauffman RG, Warner RD, Joo ST. 1994. One step closer to providing ideal pork quality for consumers in 1994. Pork Chain Quality Audit. National Pork Producers Council Publication, USA. p 143.
19. McKeith F, Meeker D, Buege D. 1994. Pork chain quality audit. *Proc Recip Meat Conf* 47: 73-74.
20. Davis GW, Smith GC, Carpenter ZL, Cross HR. 1975. Relationships of quality indicators to palatability attributes of pork loins. *J Anim Sci* 41: 1305-1317.
21. Eikelenboom G, Nanni Costa L. 1988. Fiber optic probe measurements in Landrace pigs of different halothane phenotypes. *Meat Sci* 23: 9-19.
22. van Laack RLJM, Kauffman RG, Sybesma W, Smulders FJM, Eikelenboom G, Pinheiro JC. 1994. Is colour brightness (L-value) a reliable indicator of water-holding capacity in porcine muscle? *Meat Sci* 38: 193-201.
23. Wood JD, Richardson RI, Nute GR, Fisher AV, Campo MM, Kasapidou E, Sheard PR, Enser M. 2003. Effects of fatty acids on meat quality: a review. *Meat Sci* 66: 21-32.
24. Harrington G. 1994. Consumer demands: major problems facing industry in a consumer-driven society. *Meat Sci* 36: 5-18.

(Received February 12, 2008; Accepted March 11, 2008)