한국식생활문화학회지 36(4): 362-372, 2021
J. Korean Soc. Food Cult. 36(4): 362-372, 2021

ISSN 1225-7060(Print)
ISSN 2288-7148(Online)
https://doi.org/10.7318/KJFC/2021.36.4.362

Effect of Different Slaughter Weights on Meat Quality, Fatty Acids and Flavor Component of Korean *Woori* Black Pig Loin and Belly

Van-Ba Hoa[1], Dong-Heon Song[1], Kuk-Hwan Seol[1], Sun-Moon Kang[1], Yun-Seok Kim[2], Ye-Jin Min[3], Soo-Hyun Cho[1,*]

[1]*Animal Products Utilization Division, National Institute of Animal Science, RDA*
[2]*R&D Performance Evaluation & Management Division, RDA*
[3]*Swine Science Division, National Institute of Animal Science, RDA*

Abstract

The present study was undertaken to investigate the quality characteristics of Korean *Woori* black pig (KWP) bellies and loins by different slaughter weight (SW) groups. The loin and belly samples collected from KWPs with different body weights (50, 75, 90, 105, and 120 kg) at 24 h post-mortem were used in the present investigation. The samples were analyzed for quality traits, fatty acid profiles, and volatile flavor compounds. Results showed that the fat content of the loin (8.64%) and belly samples (46.78%) was significantly higher in the 120 kg SW group compared to those of other SW groups ($p<0.05$). However, a lower protein content (12.20-12.67%) was found in the belly cuts of the heavier SW groups (105-120 kg) compared to those of the lighter SW groups ($p<0.05$). The lowest cooking loss (24.34%) was found in the loin cuts of the 120 kg SW group ($p<0.05$). Both the loin and belly cuts were observed to be redder in color with increasing SW ($p<0.05$). Higher oleic acid (C18:1, n9) and total monounsaturated fatty acid content and lower linolenic acid(C18:3, n3) and total polyunsaturated fatty acid content were observed in both cuts of the 120 kg SW group ($p<0.05$). Out of the flavor compounds identified, 11 and 17 compounds in the loin and belly, respectively, were associated with the SW. An increase in the SW resulted in increased concentrations of C18:1n9- and amino acid-derived flavor compounds. Overall, the meat samples of the heavier SW groups (120 kg) exhibited better quality and higher concentrations of volatile compounds associated with pleasant flavors. However, the meat of the 120 kg SW group also contained a much higher fat level (8.64 and 46.78% in the loin and belly, respectively) that may result in high trimming loss and hence a high rejection risk by consumers.

Key Words: Korean *Woori* black pig, belly, loin, meat quality, flavor

I. Introduction

Korean *Woori* black pig (KWP) is known as a synthetic breed that was produced by crossbreeding between pure Duroc with Korean native black pig (Kim et al. 2013). The KWP is characterized by its distinctive short and black coat color and low performance but stronger tolerance of disease compared to modern and genetically-improved breeds (Jin et al. 2001; RDA 2001). In recent years, the interest in utilization of KWP breed has been significantly increasing due to the sharply increased demand for its meat in the country. In term of meat quality, the meat of KWP is reputed for its superior quality; indicating by a more reddish in color, whiter fat, higher marbling degree and better eating quality than those from commercial Western pig breeds; (Jin et al. 2001; Cho et al. 2007a; Park et al. 2007; Kim et al. 2013; Kim & Kim 2018). Therefore, the KWP meat is considered as a premium and delicate variety regardless of their approximately 30 to 40% more expensive price compared to the other commercial pig breeds-derived meat (AHDB 2020).

In the Korean pork industry, to attain a better carcass quality grade and market price, the commercial growing-pigs (mainly commercial Western pig breeds) are usually finished when they reach a targeted body weight of around 110 kg (KAPE 2018). This slaughter weight (SW) is considered lighter compared to those in other countries such as; United Stated (120-130 kg), Italia (150-160 kg) and Germany (115-125 kg) (Correa et al. 2006; Wu et al. 2017). The SW of pig is an important factor affecting the economic profitability and meat quality as well. Most studies on the commercial pig breeds have shown that increasing SW leads to improved technological (e.g., color and water holding capacity) and

*Corresponding author: Soo-Hyun Cho, Animal Products Utilization Division, National Institute of Animal Science, RDA, Wanju 55365, Korea
Tel: +82-63-238-7351 Fax: +82-63-238-7397 E-mail: shc0915@korea.kr

eating qualities (flavor and juiciness) of pork (Ba et al. 2019; Hwang et al. 2020). However, the increase of SW (e.g., after reaching 100 kg body weight) leads to a dramatically increased fat deposition rate (Latorre et al. 2004; Serrano et al. 2008).

As above-mentioned, a huge number of studies have been conducted to investigate the meat quality characteristics for almost all the commercial pig breeds by different SW in the countries. Till now, little attention has been paid to the investigation of quality characteristics of KWP meat by SW (Cho et al. 2007b; Kim & Kim 2017). Thus, the consumers and meat producers are not well aware of meat quality differences between SW groups for KWP breed. Moreover, only the *longissimus dorsi* muscle or loin cut was used in these previous studies. Whereas, no research has been directed in the KWP towards evaluating the meat quality characteristics of the most valuable cuts such as belly among the slaughter weights. Because, belly is considered one of the most valuable cuts, its value usually exceeded the values of all other remaining cuts in a pig carcass (Uttaro et al. 2020), and its quality cannot be estimated from loin quality (Knecht et al. 2018). Thus, the aim of this study was to investigate the chemical composition, technological quality and flavor compounds of KWP loin and belly by different slaughter weights (50, 75, 90, 105 and 120 kg).

II. Materials and Methods

1. Samples

Loin (*Longissimus thoracic et lumborum)* and belly samples collected from KWPs with different SW groups (50, 75, 90, 105, and 120 kg, n=5 per SW group) in a practical plant (Jeonju, Korea) after 24 h post-mortem were used in the present investigation. Before slaughter, all the pigs were raised under identical condition and fed a same commercial meal diet. The cuts were then skinned, deboned and trimmed of external fats and connective tissues and prepared into sub-sample sizes depending on the type of analysis as described by Ba et al. (2021b). Analysis of proximate composition, color and pH, cooking loss and water holding capacity were performed on fresh samples (on the sampling day), while vacuum-packed and frozen (−20°C) samples were used for analysis of fatty acids and flavor compounds.

2. Proximate composition

The moisture, fat, protein and collagen contents were determined according to the AOAC Official Methods 2007.04 by using a Food Scan™ Lab 78810 (Foss Tecator Co., Ltd., DK) as described by Anderson (2007). Each sample was determined in duplicates.

3. pH measurement

The pH values of samples were measured using a pH*K 21 meter (NWK-Technology GmbH, Kaufering, Germany) equipped with a stainless steel and solid-state probe. The pH measurement was done by inserting the probe deeply into the muscle tissues. Prior to use, the pH meter was calibrated with pH 4.0 and 7.0 standard solutions (NWK Technology., Kaufering, Germany).

4. Meat color and cooking loss

The color and cooking loss were measured on a same transverse section (3.0 cm-thick steak) of each the sample as described by Ba et al. (2021b). After blooming for 30 min at 4°C, the color was measured on three different locations of each the sample using a standardized Minolta Chroma Meter CR-400 with a D65 illuminant*C and 2° observer (Minolta Camera Co, Osaka, Japan). The color was measured under white lighting and the results were reported as CIE L* (lightness), CIE a* (redness), CIE b* (yellowness), Chroma and hue angle (h°). Care was taken to avoid measuring on the fat area. For the cooking loss measurement, after recording their initial weights the samples were immediately placed into individual plastic bags, sealed with double clip and placed in a 72°C pre-heated water bath until the core temperature reached 70°C. Immediately after cooking, the cooked samples were cooled for 30 min under running water. After absorbing to remove the surface water, their weights were recorded. The cooking loss was calculated as the weight loss percentage during cooking.

5. Fatty acid composition

The lipid content in the samples was extracted using a solvent mixture containing chloroform: methanol (2:1, v/v) as described by Folch et al. (1957). Briefly, after grinding each the samples (Ca.10 g) was weighed and homogenized with 150 mL of the solvent mixture at 300×g for 3 min using a homogenizer (Polytron, PT-MRC 2100, Switzerland). After filtration through Whatman filter paper, the filtrate was added with approximately 20 g of Na_2SO_4, thoroughly mixed for 1 min, and then the upper lipid layer was transferred into an Erlenmeyer flask. After drying at 55°C using a rotary evaporator, the lipids layer was reconstituted with 1 mL tricosanoic acid and 1 mL of 0.5 N NaOH. Finally, the lipid

was converted to fatty acid methyl esters following the procedure of Morrison & Smith (1964). Approximately 1.0 mL of FAMEs was taken and placed into auto-sampler vials, sealed and used for fatty acids analysis. The separation of FAMEs was achieved using a gas chromatography/flame ionization detector (GC-FID, Varian Technologies, Palo Alto, CA, USA) equipped with an Omegawax capillary column (30 m×0.25 mm×0.25 μm film thickness; Supelco, Bellefonte, PA, USA). The GC oven temperature was maintained at 50°C for 1 min, and ramped at a rate of 25°C/min to 200°C, and further raised at a rate of 5°C per min to 230°C. The injection port and detector temperatures were set at 250 and 260°C respectively. Identification of fatty acids in the samples were carried out by comparing their retention times with those obtained from standard fatty acids. Individual fatty acids were expressed as relative percent (%) of total fatty acids.

6. Volatile flavor compounds analysis

Volatile flavor compounds in cooked meat samples were analyzed using the protocol of Ba et al. (2010) with suitable modifications. Briefly, prior to analysis, the samples were cooked at around 180°C on an open tin-coated grill for about 2 min. Immediately after cooking, approximately 2.0 g was weighed from each the cooked samples, and placed into 20-mL headspace vial (Agilent, Santa Clara, CA, USA) and tightly capped with PTFE-faced silicone septum. The volatile compounds were extracted using solid-phase micro-extraction (SPME) technique. The extraction of volatile compounds was carried out by inserting a SPME device containing carboxen-polydimethylsiloxane (75 μm) fiber (Supelco) into the sample vials, and the extraction was held at 60°C for 45 min. All the extraction steps were performed using an SPME auto-sampler (model: PAL RSI 85) connected to a gas chromatography (model: 8890 GC system) with mass spectrophotometry (5977B MSD, Agilent Technologies). Following the extraction, the fiber was desorbed for 5 min at 250°C, and the compounds were separated on a DB-5MS capillary column (30 m×0.25 mm i.d.×0.25 μm film thickness; Agilent J & W Scientific, Folcom, USA) using helium as a carrier gas. The GC oven was programmed to 40°C for 5 min and then increased to 250°C at a rate of 8°C/min and held at this temperature for further 5 min. The MS conditions set were: capillary direct interface temperature, 250°C, scanning mass range of 30-500 amu and rate at 5.27 scans/s. The separated peaks were identified by comparing their mass spectra with those already present in the Wiley registry library (Agilent Technologies) and/or by comparing their retention times with those of external standards. The identified compounds were quantified by comparison of their peak areas with that of internal standard (1.0 μL of 2-methyl-3-heptanone, 816 mg/mL in methanol was added together with the sample) obtained from the total ion chromatogram using a response factor of 1.

7. Statistical analysis

All the obtained data was subjected to statistical analysis using a Statistical Analysis System (SAS) Enterprise 7.1 package (SAS Institute, Cary, NC, USA, 2018). The data was analyzed by using the ANOVA procedure of the SAS. In the statistical model, the slaughter weight was considered as the fixed effect while, the quality traits, fatty acids and flavor compounds were considered as the dependent variables. Means were compared using Duncan's multiple range test. Significance was defined at $p<0.05$.

III. Results and Discussion

1. Proximate composition of KWP loin and belly by SW groups

The collagen, fat, moisture and protein contents in the loin and belly samples in the SW groups are presented in <Table 1>. The SW significantly affected almost all the contents in the loin and belly. In both cuts, the collagen content increased with increased SW ($p<0.05$). The fat content in loins did not increase as increasing SW up to 105 kg ($p>0.05$), but it did increase after reaching 120 kg of body weight ($p<0.05$). Compared with our data, those of Kim et al. (2009) and Muhlisin et al. (2014) found lower fat level (3.06-6.08%) in KWP loins slaughtered at around 95-103 kg body weights. This contrasting result may be related to the differences in feeding regime or rearing system between the studies. For the bellies, the fat content increased linearly with increased SW, but it did not differ among the 50, 75, and 90 kg SW groups ($p>0.05$), and significant difference only was observed between the 120 kg SW group (46.78%) with the other remaining groups (29.71-40.15%) except the 105 kg SW group ($p<0.05$). Compared to the fat levels (21-33%) reported by Ba et al. (2021b) and Lowell et al. (2018) for commercial pork belly slaughtered at 100 to 128 kg body weight, the fat level of KWP bellies in the 105 to 120 kg SW groups in the present study was almost two times greater. Previous studies have reported that increasing fat level could improve the meat quality, however, an overly increased fat

<Table 1> Proximate composition of Korean *Woori* black pig loin and belly as affected by slaughter weight

Slaughter weight (kg)	Loin				Belly			
	Collagen	Fat	Moisture	Protein	Collagen	Fat	Moisture	Protein
50	0.84±0.20^{ab}	4.45±1.72^{b}	73.33±0.92^{a}	22.03±0.89	1.85±0.10^{ab}	29.71±3.24^{c}	55.24±2.79^{a}	15.65±0.58^{a}
75	0.78±0.26^{b}	5.82±2.15^{b}	70.39±1.19^{c}	22.45±0.82	1.74±0.19^{b}	38.37±10.76^{bc}	47.64±7.69^{b}	13.98±2.54^{b}
90	0.87±0.17^{ab}	6.13±1.31^{b}	71.71±0.66^{b}	21.95±0.65	1.98±0.21^{a}	40.15±5.23^{bc}	47.04±4.34^{cb}	13.69±1.03^{bc}
105	0.79±0.07^{ab}	6.43±2.12^{b}	70.74±1.47^{cd}	22.22±0.60	1.73±0.37^{b}	43.92±10.29^{ab}	43.04±8.56^{cd}	12.20±1.81^{c}
120	1.01±0.30^{a}	8.64±3.12^{a}	68.74±1.91^{d}	21.84±1.05	2.01±0.29^{a}	46.78±6.50^{a}	42.29±5.71^{d}	12.67±1.20^{c}

Means within a same row with different superscripts (a,b,c,d) are significantly different (p<0.0

content has been found to be associated with a high risk of meat rejection and negatively affect the consumer's buying decision and be associated with high risk of rejection by consumers (Fernandez et al. 1999; Fortin et al. 2005). It is well recognized that slaughter of pigs at heavier weight results in an advantage of reducing the overhead costs for producers, slaughterers and processors by increasing carcass and meat weights (Alvarez-Rodríguez & Teixeira 2019). For the KWP breed, however, the increase of SW to 90-120 kg led to an excessively deposited fat level (a significant proportion of this fat is non-edible) in the belly. Because belly is one of the biggest, most preferable and valuable cuts (accounting for ca.16% of total carcass weight) in a pork carcass (Oh & See 2012). Therefore, to balance the trade-offs between carcasses and their non-edible compositional outcomes, the KWPs should be harvested before reaching 120 kg body weight.

2. Technological quality traits of KWP loin and belly by SW groups

The mean values for the technological quality traits of loin and belly among the SW groups are shown in <Table 2>. Regarding pH, its values ranged among the SW groups from 5.51 to 5.61, and 5.71 to 5.86 in the loin and belly, respectively. The pH decreased in the loin whereas, it increased in the belly as increasing the SW (p<0.05). The decrease of loin pH with increased SW may be related to more abundance of glycogen source which then underwent the postmortem glycolysis, resulting in higher lactic acid concentration. However, these pH values fell within the range (above 5.5 and below 6.0) for the normal post-rigor pork meat (Adzitey & Nurul 2011). Compared with our results, those of Kim & Kim (2018) found similar pH values (5.59-5.6) for KWP loin. With respect to cooking loss, increasing the SW reduced the cooking loss of loins (p<0.05), which agrees with findings of Hwang et al. (2020) and Ba et al. (2019), but no differences occurred among the 90, 105 and 120 kg SW groups (p>0.05). For the belly, the SW showed no effect on the cooking loss, this may be attributed to its similar moisture content and a relatively high fat level <Table 1>. Bidner et al. (2004) reported that ultimate loin pH plays the most important role in determination of loin's water holding capacity. In the present study, the higher cooking loss observed in the loins of pigs slaughtered at 50 to 90 kg body weight cannot be explained by the pH values. We assume that the decrease of loin's cooking loss with increased SW could be related to its increased fat and decreased moisture contents <Table 1> because fat and moisture contents in meat are inversely related with each other (Kim & Lee 2003).

<Table 2> Technological quality traits of Korean native black pig loin and belly as affected by slaughter weight

Slaughter weight (kg)	pH		Cooking loss (%)	
	Loin	Belly	Loin	Belly
50	5.59±0.05^{a}	5.73±0.13^{b}	36.01±2.19^{a}	11.97±1.32
75	5.56±0.04^{ab}	5.71±0.10^{b}	32.13±1.50^{a}	13.14±2.97
90	5.61±0.09^{a}	5.82±0.19^{ab}	31.05±1.11^{ab}	12.44±2.28
105	5.60±0.02^{a}	5.85±0.13^{ab}	28.97±1.34^{ab}	11.14±2.73
120	5.51±0.11^{b}	5.86±0.21^{a}	24.34±10.82^{b}	10.22±2.67

Means within a same row with different superscripts (a,b) are significantly different (p<0.05).
(-), not measured.

<Table 3> Color traits of Korean *Woori* black pig loin and belly as affected by slaughter weight

Slaughter Weight (kg)	Loin					Belly				
	CIE L*	CIE a*	CIE b*	Chroma	Hue angle	CIE L*	CIE a*	CIE b*	Chroma	Hue angle
50	53.19±3.13^{b}	5.73±1.19^{c}	4.26±1.06^{b}	7.16±1.51^{c}	36.52±4.37	61.08±6.94^{a}	8.78±2.25^{c}	6.67±1.11^{ab}	11.10±2.13^{b}	38.04±7.25^{a}
75	56.51±2.88^{a}	6.52±1.25^{bc}	4.42±1.00^{b}	7.89±1.49^{bc}	34.06±4.28	56.31±5.95^{b}	10.57±2.53^{b}	6.04±0.90^{b}	12.60±2.81^{b}	29.69±5.22^{bc}
90	55.10±2.93^{ab}	7.25±1.43^{ab}	5.03±1.09^{ab}	8.85±1.68^{ab}	34.83±4.29	53.17±8.04^{bc}	10.85±2.71^{b}	6.12±1.46^{b}	12.53±2.73^{b}	29.87±6.89^{bc}
105	55.34±3.64^{ab}	7.49±1.49^{ab}	5.30±1.03^{a}	9.13±1.66^{a}	35.74±4.82	55.38±4.66^{bc}	10.88±2.11^{b}	6.71±1.04^{ab}	12.81±2.18^{b}	32.08±4.40^{b}
120	55.84±3.57^{ab}	8.04±1.22^{a}	5.44±0.91^{a}	9.74±1.35^{a}	34.11±4.15	51.89±4.49^{c}	13.20±2.60^{a}	7.02±1.37^{a}	15.00±2.70^{a}	28.31±4.67^{c}

Means within a same row with different superscripts (a,b,c) are significantly different ($p<0.05$).

3. Instrumental meat color of KWP loin and belly by SW groups

Color, as an indicator of freshness and wholesomeness, is an important aspect of quality that influences meat purchasing decision by consumers (Purslow et al. 2020). The mean values of color traits of KWP loin and belly among the SW groups studied are presented in <Table 3>. We observed that the SW affected all the color traits. With respect to L* (lightness), its values in the loins increased to up to 75 kg body weight and remained unchanged thereafter whereas, the bellies decreased in the L* value as increasing SW ($p<0.05$). Regarding the a* (redness), in both cuts its values significantly ($p<0.05$) increased with increased SW, and a similar trend was also observed for the b* (yellowness). In both cuts, the Chroma values significantly ($p<0.05$) increased as increasing the SW whereas, an opposite trend was observed for the hue angle of belly. Furthermore, when compared to L* and a* values reported by Kim et al. (2009) and Muhlisin et al. (2014) for KWP loin slaughtered at 67-96 kg body weight, all the loin samples in the similar SW groups had similar values. However, compared to our data, those of Hwang et al. (2020) reported lower L* (47.80-48.90) and a* values (7.02-7.71) for loins of commercial pig breed slaughtered at above 100 kg body weight. Ba et al. (2021b) also reported a lower a* value for belly of commercial crossbred pigs slaughtered at above 100 kg body weight. The present results support the findings of Cho et al. (2007b), Jin et al. (2001) and Park et al. (2007), who showed higher a* value in KWP meat compared to that of commercial pig breeds. In the present study, the meat samples were collected from different body weights, which resulted in a wide variation in almost all color traits. This may be attributed to the increased total muscle pigments (e.g., myoglobin) and level of physical activity, leading to a decrease in L* and an increase in a* values of meat muscles (Monteiro et al. 2013; Florek et al. 2015).

4. Fatty acid composition in KWP loin and belly by SW groups

The fatty acid composition of KWP loin and belly among the SW groups is presented in <Table 4>. Palmitic acid (C16:0) and stearic acid (C18:0) were two the most predominant saturated fatty acids (SFA) in both cuts studied. These two fatty acids have also been found to be the main SFAs in commercial pork meat (Rentfrow et al. 2003; Wood et al. 2008; Soladoye et al. 2017; Ba et al. 2021a). No differences in C16:0 content were found among the SW groups but the level of C18:0 decreased in both the loin and belly as increasing the SW ($p<0.05$). Our results are generally in accordance with those of Wood et al. (2008) and Jayasena et al. (2015): C18:0 content decreased with increased SW. However, the decrease in C18:0 level did not cause differences in the total SFA contents among the SW groups ($p>0.05$). Oleic acid (C18:1, n9) was the main monounsaturated fatty (MUFA) we found in both the loin and belly samples. Unlike the SFA, the MUFAs such as C18:1 (n9) level significantly increased, which resulted in an increase in the total MUFA content as well as MUFA/SFA ratio in both cuts as increasing the SW ($p<0.05$). This results agree well with that of Rentfrow et al. (2003) and Wood et al. (2008), who reported an increase in C18:1(n9) and total MUFA content in commercial pork meat with increased SW. Linoleic acid (C18:2, n6) and linolenic acid (C18:3, n3) were the main polyunsaturated fatty acids (PUFA) we found in both the cuts of all the SW groups. The SW did not affect the C18:2 (n6) content in belly, which resulted in a similar total PUFA contents for all the SW groups ($p>0.05$). Whereas, the C18:2 (n6) content in loin decreased, which resulted in decreased total n6 fatty acids, PUFA and PUFA/SFA ratio in this muscle as increasing SW ($p<0.05$). It is assumed that the concentration of structural lipids (e.g., fatty acids present in cellular membrane) in muscle tissues is not affected by animal age and diet (Benz et al. 2010). It means that the

<Table 4> Relative percentage (%) of fatty acids in Korean *Woori* black pig belly and loin as affected by slaughter weight

Items	Slaughter Weight (kg)					SEM	Slaughter Weight (kg)					SEM
	50 kg	75 kg	90 kg	105 kg	120 kg		50 kg	75 kg	90 kg	105 kg	120 kg	
	Belly						Loin					
Myristic acid (C14:0)	1.41	1.37	1.32	1.38	1.38	0.13	1.48	1.51	1.48	1.57	1.38	0.11
Palmitic acid (C16:0)	27.76	27.31	27.43	28.18	27.66	1.98	28.41	29.13	28.23	30.32	27.06	2.26
Palmitoleic acid (C16:1, n7)	1.95	1.85	1.58	1.65	1.69	0.47	2.00	2.74	2.70	2.41	2.42	0.67
Stearic acid (C18:0)	14.97^{a}	14.94^{a}	13.00^{b}	14.46^{ab}	11.89^{bc}	1.25	14.60^{ab}	15.61^{a}	13.40^{b}	14.76^{ab}	12.54^{ab}	1.95
Oleic acid (C18:1, n9)	37.95^{b}	38.36^{b}	41.96^{ab}	39.58^{ab}	43.13^{a}	2.69	38.60^{b}	41.77^{ab}	44.26^{a}	43.15^{ab}	46.07^{a}	3.32
Cis-vaccenic acid (C18:1, n7)	0.07	0.04	0.05	0.06	0.05	0.001	0.04	0.06	0.09	0.06	0.08	0.02
Linoleic acid (C18:2, n6)	14.10	14.33	13.20	13.03	12.74	1.70	12.59^{a}	7.67^{b}	8.09^{b}	6.57^{b}	9.12^{b}	2.18
Gamma linoleic acid(C18:3,n6)	0.01^{bc}	0.007^{c}	0.02^{ab}	0.02^{ab}	0.03^{a}	0.07	0.03	0.01	0.02	0.01	0.01	0.01
Linolenic acid (C18:3, n3)	0.77^{a}	0.81^{a}	0.70^{ab}	0.68^{ab}	0.59^{b}	0.10	0.57^{a}	0.41^{ab}	0.33^{b}	0.31^{b}	0.46^{b}	0.11
Eicosenoic acid (C20:1, n9)	0.69^{a}	0.74^{a}	0.51^{b}	0.73^{a}	0.69^{a}	0.10	0.53	0.67	0.62	0.51	0.64	0.11
Arachidonic acid (C20:4, n6)	0.22^{a}	0.17^{a}	0.17^{a}	0.16^{a}	0.12^{c}	0.03	0.93^{a}	0.32^{bc}	0.65^{ab}	0.26^{bc}	0.16^{c}	0.27
Eicosapentaenoic acid (C20:5, n3)	0.01	0.01	0.01	0.01	.	0.001	0.04	0.01	0.02	0.01	0.01	0.01
Adrenic acid (C22:4, n6)	0.08^{a}	0.05^{bc}	0.05^{bc}	0.06^{ab}	0.04^{c}	0.001	0.16^{a}	0.07^{b}	0.10^{b}	0.06^{b}	0.05^{b}	0.03
Docosahexanoic acid (C22:6, n3)	0.02	0.01	ND	ND	ND	0.001	0.03	0.02	ND	ND	ND	0.01
SFA	44.15	43.62	41.75	44.02	40.93	2.28	44.49	46.25	43.12	46.65	40.98	3.79
UFA	55.85	56.38	58.25	55.98	59.07	2.28	55.51	53.75	56.88	53.35	59.02	3.79
MUFA	40.65^{b}	41.00^{b}	44.11^{ab}	42.02^{ab}	45.56^{a}	2.44	41.16^{b}	45.24^{ab}	47.67^{a}	46.14^{a}	49.21^{a}	3.21
PUFA	15.20	15.38	14.14	13.96	13.51	1.68	14.35^{a}	8.51^{b}	9.21^{b}	7.22^{b}	9.81^{b}	2.55
n3	0.79^{a}	0.83^{a}	0.71b	0.68^{b}	0.59b	0.10	0.63^{a}	0.43^{b}	0.35^{b}	0.32^{b}	0.47^{b}	0.12
n6	14.40	14.55	13.43	13.28	12.92	1.72	13.71^{a}	8.07^{b}	8.86^{b}	6.89^{b}	9.34^{b}	2.45
n6/n3	18.15^{b}	17.64^{b}	19.44^{b}	19.43^{b}	22.19^{a}	1.54	21.48^{ab}	18.38^{b}	25.60^{a}	21.54^{ab}	20.88^{b}	2.51
MUFA/SFA	0.93^{b}	0.94^{b}	1.06^{b}	0.96^{b}	1.12^{a}	0.10	0.93^{b}	0.98^{ab}	1.15^{ab}	1.00^{ab}	1.20^{a}	0.16
PUFA/SFA	0.34	0.35	0.34	0.32	0.33	0.05	0.33^{a}	0.19^{b}	0.23^{ab}	0.16^{b}	0.24^{ab}	0.08

SEM: Standard error of the means.
Means within a same row in each cut with different superscripts (a,b,c) are significantly different ($p<0.05$).
SFA: Saturated fatty acids; UFA: Unsaturated fatty acids; MUFA: Mono unsaturated fatty acids; PUFA: Poly unsaturated fatty acids.
ND: not detectable

differences in the fatty acid composition observed on the loin and belly samples among the SW groups is mainly caused by the fatty acid composition of the intermuscular and intramuscular fat layers. Researchers reported that the intermuscular and intramuscular fat contents are usually developed at the later growing phase of pig (from 5th month of age) through the hypertrophic pathway meanwhile, the activity of enzymes such as hexokinase and phospho-fructokinase for lipids synthesis also increases the most (Hauser et al. 1997). Additionally, it was reported that animal age affects the activity of stearoyl-CoA desaturase that is mainly responsible for catalyzing the *de novo* synthesis of fatty acids and the conversion of stearic into oleic acid as well as the other enzymes (e.g., heart fatty acid-binding proteins) that is responsible in the uptake of dietary fatty acids (Renaville et al. 2018).

On the other hand, the fatty acid composition in meat is of importance both from technological and eating quality point of view. Studies have reported that the higher the proportion of C18:1n9 in meat the greater the acceptability of the meat (Smith 2016), and this fatty acid is the most important component for development of cooked meat flavor (Ba et al. 2013; Lee et al. 2017). With respect to technological level, fatty acid composition largely influences the firmness/softness of pork belly. According to Pork Composition and Quality Assessment Procedures (Soladoye et al. 2017), quality pork fat must have <15% PUFA and <14% C18:2 (n6); pork fat containing >15% PUFA and >14% C18:2 (n6) is associated with belly softness. Also, the SFA content has been reported to affect the overall pliability of pork bellies since it is positively correlated with belly firmness (Trusell et al. 2011). However, in the present study, no differences in the

<Table 5> Concentration (μg/g) of volatile flavor compounds in cooked Korean *Woori* black pig belly and loin by slaughter weights

Flavor compounds	RT (min)	IM[1)]	Slaughter Weight (kg)				SEM	Slaughter Weight (kg)				SEM
			75	90	105	120		75	90	105	120	
			Belly					Loin				
Aldehydes												
2-methylpentanal	1.6608	MS,STD	0.008^{b}	0.030^{ab}	0.034^{a}	0.033^{a}	0.014	0.040	0.040	0.019	0.038	0.013
2-methylpropanal	1.8778	MS,STD	0.001	0.004	0.009	0.004	0.003	0.004	0.007	0.003	0.005	0.003
Butanal	2.0634	MS,STD	ND	0.002	0.002	0.003	0.001	ND	0.002	0.001	0.003	0.000
3-methylbutanal	2.5926	MS,STD	ND	ND	0.014	0.016	0.011	0.005	0.011	0.004	0.006	0.003
2-methylbutanal	2.7039	MS,STD	ND	0.004	0.014	0.024	0.013	0.007	0.020	0.008	0.016	0.005
Pentanal	3.154	MS,STD	0.128^{b}	0.263^{a}	0.245^{a}	0.307^{a}	0.086	0.194^{ab}	0.171^{b}	0.163^{b}	0.330^{a}	0.082
Hexanal	5.8122	MS,STD	2.045	3.956	3.922	3.728	0.304	3.654^{ab}	2.310^{b}	2.229^{b}	4.577^{a}	0.885
Heptanal	8.9842	MS,STD	0.113^{b}	0.183^{ab}	0.203^{a}	0.201^{a}	0.048	0.192^{b}	0.154^{b}	0.150^{b}	0.264^{a}	0.067
4-Heptenal	10.4616	MS,STD	0.008^{b}	0.032^{a}	0.025^{a}	0.034^{a}	0.011	0.022	0.016	0.029	0.038	0.015
Benzaldehyde	10.541	MS,STD	0.027^{b}	0.056^{a}	0.058^{a}	0.059^{a}	0.013	0.074	0.071	0.066	0.093	0.033
Octanal	11.6266	MS,STD	0.107^{b}	0.146^{b}	0.268^{a}	0.296^{a}	0.057	0.290^{b}	0.305^{b}	0.336^{b}	0.509^{a}	0.117
Benzeneacetaldehyde	12.5696	MS,STD	ND	ND	0.008	0.007	0.003	0.007	0.010	0.005	0.010	0.003
E,2-Octenal	12.8868	MS,STD	0.013^{b}	0.023^{ab}	0.034^{a}	0.035^{a}	0.009	0.024^{b}	0.019^{b}	0.018^{b}	0.044^{a}	0.012
Nonanal	13.8771	MS,STD	0.136^{b}	0.205^{b}	0.340^{a}	0.417^{a}	0.063	0.292^{b}	0.301^{b}	0.382^{b}	0.532^{a}	0.150
E,2-nonenal	14.9997	MS,STD	0.034	0.028	0.037	0.051	0.022	0.025^{b}	0.040^{ab}	0.039^{ab}	0.078^{a}	0.035
Decanal	15.8893	MS,STD	0.006	0.003	0.006	0.008	0.004	0.010	0.021	0.035	0.031	0.023
E,E, 2,4-nonadienal	16.0483	MS,STD	0.002	0.004	0.004	0.012	0.004	0.003	0.003	ND	0.006	0.002
E,2-decenal	16.9166	MS,STD	0.018^{b}	0.015^{b}	0.034^{a}	0.044^{a}	0.000	0.035	0.048	0.058	0.070	0.033
E,E, 2,4-decadienal	17.4938	MS,STD	0.012	0.004	0.009	0.008	0.005	0.005	0.013	0.010	0.014	0.007
2-undecenal	18.69	MS,STD	0.007^{b}	0.005^{b}	0.018^{a}	0.024^{a}	0.006	0.021	0.042	0.052	0.060	0.030
Alcohols												
1-Butanol	2.699	MS,STD	ND	0.006	0.006	0.007	0.001	ND	ND	ND	0.007	0.002
2-propen-1-ol	2.932	MS	ND	0.004	0.004	0.005	0.002	ND	ND	ND	0.003	0.000
1-Pentanol	4.7849	MS,STD	0.088	0.145	0.196	0.105	0.075	0.123	0.076	0.039	0.107	0.049
1-Hexanol	8.0627	MS,STD	0.025^{b}	0.033^{b}	0.081^{a}	0.080^{a}	0.002	0.054	0.063	0.058	0.069	0.002
1-Heptanol	10.827	MS,STD	0.013	0.012	0.024	0.018	0.008	0.012	0.028	0.048	0.040	0.031
1-Octen-3-ol	11.097	MS,STD	0.032^{b}	0.061^{ab}	0.081^{a}	0.073^{a}	0.007	0.048	0.051	0.031	0.071	0.024
2-ethyl-1-hexanol	12.2408	MS	0.037	0.012	0.019	0.017	0.015	0.019	0.031	0.020	0.044	0.005
1-Octanol	13.1569	MS,STD	0.013^{b}	0.015^{b}	0.028^{a}	0.029^{a}	0.008	0.016	0.021	0.028	0.041	0.016
Hydrocarbons												
2-Butanone	2.0896	MS,STD	0.005^{b}	0.007^{b}	0.012^{ab}	0.015^{a}	0.005	0.009^{b}	0.020^{ab}	0.012^{ab}	0.017^{a}	0.006
Toluene	4.7161	MS,STD	0.009^{b}	0.043^{ab}	0.098^{ab}	0.068^{a}	0.034	0.007	0.046	0.020	0.046	0.014
Ethylbenzene	7.7503	MS,STD	0.019^{b}	0.017^{b}	0.214^{ab}	0.570^{a}	0.018	0.023^{b}	0.081^{a}	0.093^{a}	0.121^{a}	0.027
Xylene	7.9939	MS,STD	0.028^{b}	0.033^{b}	0.226^{a}	0.249^{a}	0.064	0.049^{b}	0.124^{ab}	0.156^{a}	0.161^{a}	0.050
2,3-octanedione	11.1817	MS,STD	0.048	0.147	0.195	0.183	0.070	0.063^{ab}	0.040^{b}	0.041^{b}	0.092^{a}	0.027
5-ethyl-2-methyloctane	12.3414	MS	0.025	0.040	0.023	0.020	0.002	0.042	0.076	0.028	0.056	0.017
2,6-dimethyloctane	12.7915	MS	0.008	0.008	0.011	0.009	0.006	0.017	0.030	0.017	0.024	0.012
2,5,9-trimethyldecane	13.0034	MS	0.004	0.006	0.010	0.007	0.003	0.012	0.017	0.008	0.014	0.006
4,8-dimethyldecane	13.2628	MS	0.005	0.008	0.009	0.006	0.003	0.008	0.012	0.008	0.010	0.005
Octanoic acid	15.148	MS,STD	0.009	0.008	0.013	0.003	0.005	0.008	0.034	0.021	0.008	0.014
Dodecane	15.7622	MS,STD	0.011	0.007	0.010	0.009	0.005	0.015	0.007	0.017	0.016	0.013
Tetredecane	19.262	MS,STD	0.008	0.007	0.009	0.010	0.002	0.009	0.011	0.010	0.014	0.004
Sulfur-and nitrogen-containing compounds												
Methanethiol	1.5234	MS,STD	ND	ND	0.004	0.009	0.004	ND	0.004	0.002	0.002	0.000
1-propanethiol	1.5658	MS	ND	ND	0.007	0.010	0.004	0.074	0.021	0.009	0.021	0.029
Carbon disulfide	1.8036	MS,STD	0.005	0.004	0.008	0.004	0.003	0.007	0.007	0.004	0.006	0.003
2,5-dimethylpyrazine	9.1856	MS,STD	ND	ND	ND	ND	NM	ND	ND	0.113	0.179	0.015
3-ethyl-2,5-dimethylpyrazine	13.3741	MS,STD	ND	ND	0.011	0.008	0.006	0.006	0.012	0.007	0.012	0.004

[1)]IM: Identification method: The compounds were identified by mass spectra (MS) from library or external standards (STD).
Means within a same row in each cut with different superscripts (a,b,c) are significantly different ($p<0.05$).
SEM: Standard error of the means.
ND: not detectable; NM: Not measured.

SFA content occurred among the SW groups ($p>0.05$) <Table 3>. Besides the fatty acids, moisture content also contributes to belly softness; the higher the moisture content in meat the softer the meat (Soladoye et al. 2017). From a human nutritional point of view, a high dietary total n-3 PUFA content and a low n6/n3 ratio play an important role in the immune response and prevention of cardiovascular disease (USDA 1994). In the present study, a decrease in the n3 PUFAs and an increase in the n3/n6 ratio in all the meat samples as increasing the SW was observed. Thus, apart from the nutritional value, increasing SW led to increased total MUFA content, and decreased total PUFA and moisture contents, which may improve the flavor characteristics and technological firmness of the KWP belly.

5. Volatile flavor compounds of KWP loin and belly by SW groups

Consumer studies have shown that flavor is a very important trait for the eating quality of cooked meat (Mottram 1998; Maughanet al. 2012). Odors, as a part of meat flavor, detected by odor epithelium in the nose are developed by volatile flavor compounds which are produced through a variety of chemical processes during cooking of meat (Mottram 1998). A total of 45 compounds comprising 20 aldehydes, 8 alcohols, 12 hydrocarbons and 5 sulfur-and nitrogen-containing compounds, were detected from the cooked KWP belly and loin <Table 5>. Thus, aldehydes represented the most predominant class, followed by hydrocarbon, alcohol, and sulfur-and nitrogen-containing compound classes in both belly and loin samples. In general, a majority of these compounds has been reported in cooked pork of commercial breeds (Ba et al. 2019; Yang et al. 2018). The statistical analysis revealed that 11 and 17 flavor compounds in the loin and belly, respectively were associated with SW ($p<0.05$). Based on the formation origin (Ba et al. 2013; Mottram 1998), all of these compounds were likely arisen from thermal degradation of fatty acids and Strecker degradation of amino acids. We observed that the most noticeable differences in the flavor profiles in both cuts among the SW groups were the oleic acid and amino acids-derived compounds. Of which, almost all the oleic acid-derived compounds such as octanal, nonanal, decanal and E,2-decenal significantly ($p<0.05$) increased in both cuts as increasing the SW to 105 or 120 kg. This is likely to be associated with the increased level of oleic acid with increased SW as above-mentioned <Table 4>. These oleic acid-derived aldehydes (octanal, nonanal, decanal and E,2-decenal) with low odor-detection thresholds and possessing pleasant odor notes (e.g., fruity, fatty, sweet and oily flavors) are very important for cooked meat flavor (Machiels et al. 2004; Rochat &Chaintreau 2005). With respect to the amino acids-derived compounds, we observed that the levels of 2-methylpentanal, toluene and ethylbenzene in the belly significantly increased with increased SW ($p<0.05$). Also, 3-methylbutanal and 2-methylbutanal were not detectable in the belly samples of 75 and 90 kg SW groups. A similar phenomenon was also observed for the sulfur-and nitrogen-containing compounds; almost all of them such as methanethiol associated with sweet odor (Machiels et al. 2004), 2,5-dimethylpyrazine and 3-ethyl-2,5-dimethylpyrazine associated with roasty odor (Mottram 1998) were not found in the belly or loin samples of 75 and 90 kg SW groups. It is well recognized that these sulfur-and nitrogen-containing compounds are derived from the Maillard reaction between amino acids and reducing sugars (Mottram 1998). Thus, the results indicating the absences of these Maillard compounds in the belly and loin samples may be attributed to a low level of free amino acids in these samples when slaughtering at lighter body weights (70 to 90 kg). Overall, the SW considerably affected the volatile flavor profiles in cooked belly and loins, and increasing the SW may result in enhanced flavor characteristics of the KWP meat.

Conclusion

Summing up, increasing SW up to 120 kg resulted in an excessively increased fat content in the loin (8.64%) and belly (46.78%), these fat levels were almost two times greater compared to those reported for the same cuts of commercial pig breeds in literature. In term of meat quality, a lower cooking loss and a redder color were found in the meat of pigs slaughtered at heavier weights (120 kg). The 120 kg SW group had higher C18:1 (n9) and total MUFA contents whereas, it had lower the C18:3 (n3) and total PUFA contents compared to those in the lighter SW groups. Eleven and 17 flavor compounds in loin and belly, respectively were associated with the SW. Increasing the SW resulted in the increased concentrations of C18:1n9- and amino acids-derived volatile compounds. Overall, meat of heavier SW groups exhibited a better technological quality and contained higher concentrations of flavor compounds associated with pleasant flavors. However, the meat of 120 kg SW group contained much high fat level that may cause a high trimming loss and being associated with high

rejection risk by consumers. Further study should be conducted to investigate the taste-active compounds such as free amino acids and eating quality the KWP meat among the SW groups.

Author's Orcid numbers

Van-Ba Hoa (Postdoctoral researcher at Animal Products Utilization Division, National Institute of Animal Science, RDA, Wanju 55365, Korea, 0000-0001-8725-1504)

Dong-Heon Song (Postdoctoral researcher at Animal Products Utilization Division, National Institute of Animal Science, RDA, Wanju 55365, Korea, 0000-0002-4670-3321)

Kuk-Hwan Seol (Senior researcher at Animal Products Utilization Division, National Institute of Animal Science, RDA, Wanju 55365, Korea, 0000-0002-0907-882X)

Sun-Moon Kang (Researcher at Animal Products Utilization Division, National Institute of Animal Science, RDA, Wanju 55365, Korea, 0000-0003-3947-4337)

Yun-Seok Kim (Researcher at R&D Performance Evaluation & Management Division, RDA, Jeonju 54875, Korea, 0000-0003-4186-7877)

Ye-Jin Min (Researcher at Swine Science Division, National Institute of Animal Science, Rural Development Administration, Cheonan 31000, Korea, 0000-0002-3083-1513)

Soo-Hyun Cho (Senior researcher at Animal Products Utilization Division, National Institute of Animal Science, RDA, Wanju 55365, Korea, 0000-0002-8073-8771)

Acknowledgment

This study was supported by 2021-Postdoctoral Fellowship Program of National Institute of Animal Science (Project No. PJ014918), Rural Development Administration, Republic of Korea.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

References

Adzitey F, Nurul H. 2011. Pale soft exudative (PSE) and dark firm dry (DFD) meats: causes and measures to reduce these incidences-a mini review. Int. Food Res. J., 18:11-20

Agriculture and Horticulture Development Board (AHDB). 2020. The Pork Market in Korea. Available at: http://projectblue.blob.core.window.net/media/Defaut/what%20do/Export/KoreanPorkReport3725_200708WEB.pdf. Assessed on May 6th. 2021

Alvarez-Rodrígueza J, Teixeira A. 2019. Slaughter weight rather than sex affects carcass cuts and tissue composition of Bisaro pigs. Meat Sci., 154:54-60

Anderson S. 2007. Determination of fat, moisture, and protein in meat and meat products by using the FOSS FoodScan™ near-infrared spectrophotometer with FOSS artificial neural network calibration model and associated database: collaborative study. J. AOAC. Int., 90:1073-1083

Ba HV, Amna T, Hwang IH. 2013. Significant influence of particular unsaturated fatty acids and pH on the volatile compounds in meat-like model systems. Meat Sci., 94:480-488

Ba HV, Oliveros MC, Ryu KS, Hwang I. 2010. Development of analysis condition and detection of volatile compounds from cooked Hanwoo beef by SPME-GC/MS analysis. Korean J. Food Sci. Anim. Resour., 30:73-86

Ba HV, Seo HW, Seong PN, Cho SH, Kang SM, Kim YS, Moon SS, Choi YM, Kim JH. 2019. Live weights at slaughter significantly affect the meat quality and flavor components of pork meat. Anim. Sci. J., 90:667-679

Ba HV, Seo HW, Seong PN, Cho SH, Kang SM, Kim YS, Moon SS, Kim JH, Seol KH. 2021b. Back-fat thickness as a primary index reflecting the yield and overall acceptance of pork meat. Anim. Sci. J., 92:e13515

Ba HV, Seol KH, Seo HW, Seong PN, Kang SM, Kim YS, Moon SS, Kim JH, Cho SH. 2021a. Investigation of physiochemical and sensory quality differences in the pork belly and shoulder butt cuts with different quality grade. J. Food Sci. Anim. Resour., 41:224-236

Benz JM, Linneen SK, Tokach MD, Dritz SS, Nelssen JL, DeRouchey JM, et al. 2010. Effects of dried distillers grains with solubles on carcass fat quality of finishing pigs. J. Anim. Sci., 88:3666-3682

Bidner BS, Ellis M, Brewer MS, Campion D, Wilson ER, McKeith FK. 2004. Effect of ultimate pH on the quality characteristics of pork. J. Mus. Foods., 15:139-154

Cho SH, Seong PN, Kim JH, Park BY, Kwon OS, Ha KH, Kim DH, Ahn CN. 2007a. Comparison of meat quality, nutritional, and sensory properties of Korean native pigs by gender. Korean J. Food Sci. Anim. Resour., 27:475-81

Cho SH, Park BY, Kim JH, Kim MJ, Seong PN, Kim YJ, Kim DH, Ahn CN. 2007b. Carcass yields and meat quality by live weight of Korean native black pigs. J. Anim. Sci. Technol., 49:523-30

Correa JA, Faucitano L, Laforest JP, Rivest J, Marcou M, Gariepy C. 2006. Effects of slaughter weight on carcass composition and meat quality in pigs of two different growth rates. Meat Sci., 72:91-99

Fernandez X, Monin G, Talmant A, Mourot J, Lebret B. 1999.

Influence of intramuscular fat content on the quality of pig meat-2. Consumer acceptability of m. *longissimus lumborum*. Meat Sci., 53:67-72

Florek M, Domaradzki P, Skałecki P, Stanek P, Litwińczuk Z. 2015. *Longissimus lumborum* quality of Limousine suckler beef in relation to age and post-mortem vacuum ageing. J. Anim. Sci. 15:785-797

Folch J, Lees M, Stanley GHS. 1957. A sample method for the isolation and purification of total lipid from animal tissue. J. Biol. Chem., 226:497-500

Fortin A, Robertson WM, Tong AKW. 2005. The eating quality of Canadian pork and its relationship with intramuscular fat. Meat Sci., 69:297-305

Hauser N, Mourot J, De Clercq L, Genart C, Remacle C. 1997. The cellularity of developing adipose tissues in Pietrain and Meishan pigs. Rep. Nutr. Devel., 33:617-625

Hwang YH, Lee SJ, Lee EY, Joo ST. 2020. Effects of carcass weight increase on meat quality and sensory properties of pork loin. J. Anim. Sci. Technol., 62:753-760

Jayasena DD, Nam KC, Kim JJ, Jo C. 2015. Association of carcass weight with quality and functional 1 properties of Hanwoo (Korean native cattle) beef. Anim. Prod. Sci., 55:680-690

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. J. Food Sci. Anim. Resour., 21:142-8

Kim CJ, Lee ES. 2003. Effects of quality grade on the chemical, physical and sensory characteristics of Hanwoo (Korean native cattle) beef. Meat Sci., 63:397-405

Kim DH, Seong PN, Cho SH, Kim JH, Lee JM, Jo C, et al. 2009. Fatty acid composition and meat quality traits of organically reared Korean native black pigs. Lives Sci., 120: 96-102

Kim DW, Kim KH, Hong JK, Cho KH, Sa SJ, Park JC, Choi SH. 2013. Comparison of carcass characteristics, meat quality, amino acids contents, and fatty acid profiles of Korea native pig by gender. Rep. Dev. Biol., 37: 129-134

Kim GW, Kim HY. 2017. Effects of carcass weight and back-fat thickness on carcass properties of Korean native pigs. J. Food Sci. Anim. Resour., 37:385-391

Kim GW, Kim HY. 2018. Physicochemical properties of *M. longissimus dorsi* of Korean native pigs. J. Anim. Sci. Technol., 60:6

Knecht D, Duziński K, Jankowska-Mąkosa A. 2018. Pork ham and belly quality can be estimated from loin quality measurements? Meat Sci., 145:144-149

Korea Institute of Animal Products Quality Evaluation [KAPE]. 2018. Korea pork grading standards (Notification No. 2018-109). Available at http://www.ekape.or.kr/index.do. Accessed at March 30th 2021

Latorre MA, Lazaro R, Valencia DG, Medel P, Mateos GG. 2004. The effects of sex and slaughter weight on the growth performance, carcass traits, and meat quality characteristics of heavy pigs. J. Anim. Sci., 82:526-533

Lee JY, Oh DY, Kim HJ, Jang GS, Lee SU. 2017. Detection of superior genotype of fatty acid synthase in Korean native cattle by an environment-adjusted statistical model. Asian-Australian J. Anim. Sci., 30:765-772

Lowell JE, Bohrer BM, Wilson KB, Overholt MF, Harsh BN, Stein HH, Dilger AC, Boler DD. 2018. Growth performance, carcass quality, fresh belly characteristics, and commercial bacon slicing yields of growing-finishing pigs fed a subtherapeutic dose of an antibiotic, a natural antimicrobial, or not fed an antibiotic or antimicrobial. Meat Sci., 136:93-103

Machiels D, Istasse L, van Ruth SM. 2004. Gas chromatography-olfactometry analysis of beef meat originating from differently fed Belgian Blue, Limousin and Aberdeen Angus bulls. Food Chem., 86:377-383

Maughan C, Tansawat R, Cornforth D, Ward R, Martini S. 2012. Development of a beef flavor lexicon and its application to compare the flavor profile and consumer acceptance of rib steaks from grass- or grain-fed cattle. Meat Sci., 90:116-121

Monteiro ACG, Gomes E, Barreto AS, Silva MF, Fontes MA, Bessa RJB, Lemos JPC. 2013. Eating quality of "Vitela Tradicional do Montado"-PGI veal and Mertolenga-PDO veal and beef. Meat Sci., 94:63-68

Morrison WR, Smith LM. 1964. Preparation of fatty acid methylesters and dimethylacetals from lipid with boron fluoridemethanol. J. Lipid. Res., 5:600-608

Mottram DS. 1998. Flavor formation in meat and meat products: A review. Food Chem., 62:415-424

Muhlisin, Panjono, Lee SJ, Lee JK, Lee SK. 2014. Effects of crossbreeding and gender on the carcass traits and meat quality of Korean native black pig and Duroc crossbred. Asian-Australas. J. Anim. Sci., 27:1019-25

Oh SH, See MT. 2012. Pork preference for consumers in China, Japan and South Korea. Asian-Australas. J. Anim. Sci., 25:143-50

Park BY, Kim NK, Lee CS, Hwang IH. 2007. Effect of fiber type on postmortem proteolysis in *longisimus* muscle of Landrace and Korean native black pigs. Meat Sci., 77:482-491

Purslow PP, Warner RD, Clarke FM, Hughes JM. 2020. Variations in meat color due to factors other than myoglobin chemistry; a systhesis of recent findings (invited review). Meat Sci., 159:107941

Renaville B, Bacciu N, Lanzoni M, Mossa F, Piasentier E. 2018. Association of single nucleotide polymorphisms in fat metabolism candidate genes with fatty acid profiles of muscle and subcutaneous fat in heavy pigs. Meat Sci., 139:220-227

Rentfrow G, Sauber TE, Allee GL, Berg EP. 2003. The influence of diets containing either conventional corn, conventional corn with choice white grease, high oil corn, or high oil high oleic corn on belly/bacon quality. Meat Sci., 64:459-

466

Rochat S, Chaintreau A. 2005. Carbonyl odorants contributing to the in-oven roast beef top note. J. Agr. Food Chem., 53:9578-9585

Rural Development Administration (RDA). 2001. Korean Native Black Pig (standard farm textbook-121). pp. 1-22

Serrano MP, Valencia DG, Fuentetaja A, Lazaro R, Mateos GG. 2008. Effect of gender and castration of females and slaughter weight on performance and carcass and meat quality of Iberian pigs reared under intensive management systems. Meat Sci., 80:1122-1128

Smith SB. 2016. Marbling and its nutritional impact on risk factors for cardiovascular disease. Korean J. Food Sci. Anim. Resour., 36:435-444

Soladoye OP, Uttarob B, Zawadski S, Dugan MER, Gariépyc C, Aalhus JL, Shand P, Juárez M. 2017. Compositional and dimensional factors influencing pork belly firmness. Meat Sci., 129:54-61

Trusell KA, Apple JK, Yancey JWS, Johnson TM, Galloway DL, Stackhouse RJ. 2011. Compositional and instrumental firmness variations within fresh pork bellies. Meat Sci., 88:472-480

USDA. Departament of Health. 1994. Nutritional aspect of cardiovascular disease. Report on Health and Social Subject No. 46. London, United Kingdom: Her Majesty' Stationary Office

Uttaro B, Zawadski S, Juarez M. 2020. An approach for objective and automated identification of pork belly firmness. Meat Sci., 169:108221

Wood JD, Enser M, Fisher AV, Nute GR, Sheard PR, Richardson RI, Hugles SI, Whittington FM. 2008. Fat deposition, fatty acid composition and meat quality: A review. Meat Sci., 78:343-358

Wu F, Vierck KR, DeRouchey JM, O'Quinn TG, Tokach MD, Goodband RD et al. 2017. A review of heavy weight market pigs: status of knowledge and future needs assessment. Transl. Anim. Sci., 1: 1-15

Yang Y, Sun Y, Pan D, Wang Y, Cao J. 2018. Effects of high pressure treatment on lipolysis-oxidation and volatiles of marinated pork meat in soy sauce. Meat Sci., 145:186-194

Received July 26, 2021; revised August 26, 2021; accepted August 27, 2021