

Effects of the slaughter weight of non-lean finishing pigs on their carcass characteristics and meat quality

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Competing interests

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

Abstract

The present study aimed to assess the feasibility of increasing the slaughter weight (SW) of non-lean finishing pigs to improve their meat quality. A total of 36 (Landrace × Yorkshire) × Duroc gilts and barrows were slaughtered at 115 (Av), 125 (Hi), or 135 (XHi) kg, followed by physicochemical analyses and sensory evaluation on their *longissimus dorsi* (LD) and *Semi-membranosus* (SM) muscles. Backfat thickness was greater ($p < 0.05$) for the XHi (31.2 mm) and Hi (29.3 mm) groups than for Av (25.0 mm). Dressing percentage and yield of the belly per whole carcass were also slightly greater for XHi and Hi vs. Av. The intramuscular fat (IMF) content of SM was greater for XHi (2.64%) than for Av (1.83%) and Hi (2.04%) and also was correlated with SW ($r = 0.55$). The pH value, lightness, redness, drip loss, shear force, and moisture and protein contents of LD and SM, as well as IMF content of LD, were unaffected by SW. Percentages of 14:0, 16:0, and total saturated fatty acids (FA) were less for Hi and XHi vs. Av in SM, those of total unsaturated FA, 18:2, 20:4, and n-6 being opposite; FA composition of LM was not influenced by SW except for a reduced 18:0 percentage for XHi vs. Av. The sensory score was less for XHi vs. Av for odor in fresh LD and SM, and less for Hi and XHi vs. Av for aroma in fresh LM; scores for color, drip loss, marbling, and acceptability were unaffected by SW. As for cooked muscles, none of the scores for color, aroma, flavor, juiciness, tenderness, and acceptability was affected by SW, except for a greater LD color score for Hi and XHi vs. Av. Collectively, the results suggested that the increased yield of the carcass and belly due to increased SW is outbalanced negatively by excessive backfat deposition in production efficiency, whereas the SW increase exerts little influence on overall sensory quality of fresh or cooked meat. Production of non-lean market pigs outweighing 115 kg therefore will be uneconomical unless consumers pay a substantial premium for the over-fattened pork.

Keywords: Finishing pig, Slaughter weight, Loin, Ham, Physicochemical characteristics, Sensory attribute

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Availability of data and material

Upon reasonable request, the datasets of this study can be available from the corresponding author.

Authors' contributions

Conceptualization: Lee CY, Song DH, Song YM.

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Ethics approval and consent to participate

All experimental protocols involving animals of the present study were approved by the Institutional Animal Care and Use Committee (IACUC) of Gyeongsang National University (GNU-210906-P0077).

INTRODUCTION

The slaughter weight (SW) of finishing pigs is a significant economic and technical factor that greatly affects pork quality as well as production efficiency and profitability of pig production [1–3]. Lee et al. [4] and Park et al. [5–7] have shown that backfat thickness (BFT), dressing percentage, and pork belly yield increased as the SW of finishing pigs in the range of 110–138 kg increased. Subsequently, Jeong et al. [8] and Park and Lee [1] analyzed the pooled data of these studies [4–7] and showed that sensory scores of fresh loin and ham, including those for marbling, were improved as SW increased from 110 to 125 kg, with no further changes beyond 125 kg, although sensory quality attributes of cooked loin and ham were virtually unaffected by SW. Moreover, the SW increase was found to render an increase in the redness of meat color, which is the most important factor determining the retail selection of meat [9,10].

The SW seemingly influences meat quality primarily through its effects on fat metabolism. Intramuscular fat (IMF), which increases marbling of fresh meat as well as the sensory attributes of cooked meat, including flavor, is known to increase with an increase in SW [11,12]. The IMF in the pork loin in the previous studies [4–7] indeed increased with the increase of SW, albeit to a limited extent, which did not influence sensory properties of cooked meat [8]; limited data regarding IMF for the ham precluded any assessment regarding the effect of SW on meat quality. More specifically, fatty acid (FA) composition of the meat also influences meat quality and palatability [9,11–13], but the effects due to the increased age or SW of finishing pigs on FA composition of the loin in the aforementioned studies [4–7] were not consistent.

Besides SW, genetic leanness or whole-body adiposity represented by BFT of growing pigs, as well as their plane of nutrition, also influences pork quality [11,14–16]. It has been well documented in growing pigs that the marbling fat is greater in pig carcasses having greater BFT than those with less BFT [13] and that average daily gain (ADG) increases with an increase in dietary energy density or lysine:calorie ratio, whereas BFT and IMF increase with reduced ADG at a suboptimal lysine:calorie ratio [17–19]. In this connection, domestic market pigs have much greater BFT than those in Western countries to varying extents, as could be exemplified by their BFT spanning from 20 to over 30 mm, with an average of 21.8 mm at a 117-kg average market weight [20], compared to 19-mm BFT and 130-kg live weight for typical market pigs in the U.S.A. [21, 22]. Regarding the previous studies [4–8], the experimental pigs had 22.0 mm of overall average BFT at 122.5-kg SW, which fell on the medium lean category domestically. However, the diets used in those studies [4–7] were far from common in that their energy densities (3.0–3.2 Mcal DE/kg) were much less than the NRC [21,23] recommendation (3.4 Mcal DE/kg), whereas their lysine content (0.85% or 0.90%) were greater than the latter (0.60% to 0.80%). It is therefore unknown if non-lean pigs having high BFT could be used to improve their meat quality under commercial production conditions where the plane of nutrition is commonly equal to or greater than the NRC [21] recommendation.

The present study was aimed at assessing the feasibility of increasing the SW of non-lean pigs reared on medium-high planes of nutrition from the standpoints of production efficiency and pork quality.

METHODS

Feeding and slaughtering

All experimental protocols involving animals of the present study were approved by the Institutional Animal Care and Use Committee (IACUC) of Gyeongsang National University (GNU-

210906-P0077). The (Landrace × Yorkshire) × Duroc finisher pigs with relatively high BFT used in the present study had been reared on commercial grower and finisher diets on a commercial swine farm with their planes of nutrition comparable to those of NRC [21] recommendations for growing-finishing pigs with a high-medium lean growth rate (Table 1) as described by Yang et al. [16,24]. The present experiment was performed under a 2 (sex) × 3 [SW; ‘Average’ (Av; 115 kg), ‘High’ (Hi; 125 kg), and ‘Extra-high’ (XHi; 135 kg)] factorial arrangement of treatments. Each of the Av, Hi, and XHi groups was assigned six barrows and six gilts weighing approximately 90, 100, and 110 kg, respectively, in six pens of 17 pigs, with one pen for each sex × SW combination, after which the 36 selected animals were fattened 5 more wks within their own pens. The experimental animals were transported to a local abattoir upon measurement of their live weights and slaughtered the following day. After scalding, grading as per MAFRA [25] standards, and overnight chilling of the carcass, the belly, ham, and loin were dissected from the left half-carcass of each animal and transported to the laboratory in a refrigerator car. The BFT measurement provided by the abattoir was adjusted for the desired SW using the slope of regression of BFT on SW in each sex as described by Yang et al. [16].

Physicochemical analysis

For the evaluation of the yield and muscle:fat balance of the belly, this primal was weighed and cut at the 11th rib where the fat content of the primal is greatest [2]. After removal of a 1 cm-thick slice from the cut surface, the cross-section of the slice at the 11th rib was photographed at a fixed vertical distance followed by quantitating the areas for the fat and muscle of the photo image by computer scanning. As for the loin and ham, the *longissimus dorsi* muscle (LM) and semimembranosus muscle (SM) were removed from the former and latter, respectively, for physicochemical and sensory analyses described below.

Physicochemical characteristics of the muscle, including pH, CIE [26] color, drip loss, cooking loss, and Warner-Bratzler shear force were determined as previously described [14,27]. Contents of moisture, protein, and fat of the muscle were determined by the oven-drying and Kjeldahl and Soxhlet extraction methods, respectively, following the procedures of AOAC [28]. Composition of FA of the muscle was determined by gas chromatography using the capillary column following extraction of total lipids by the method of Folch et al. [29] as described [14,27].

Sensory evaluation

The sensory attribute of the muscle was evaluated by seven panelists who had been trained in the intramural meat science and processing lab following the guidelines of Meilgaard et al. [30]. Briefly, each attribute was scored according to a 9-point hedonic scale ranging from 1 for the poorest to 9 for the best regardless of the positive or negative nature of the evaluated attribute as described by

Table 1. Phase-feeding program and nutritional specification of the diets for the experimental animals

Item	Diet		
	Phase I ¹⁾	Phase II ²⁾	Phase III ³⁾
Interval of BW (kg)	20-43	43-72	> 72 kg
Nutritional specification			
ME (Mcal/kg)	3.35	3.35	3.25
Total lysine (%)	1.20	1.02	0.80

¹⁾⁻³⁾Each was a commercial diet, with its composition of ingredients unavailable. The pigs used for the present experiment were fed the phase I, -II, and -III diets during the indicated intervals of body weights, respectively.

BW, body weight; ME, metabolizable energy.

Jin et al. [27] and Park et al. [5,6].

Statistical analysis

All data were analyzed using the General Linear Model procedure of SAS (SAS/STAT Software for PC. Release 9.2, SAS Institute, Cary, NC, USA). The statistical model included the sex and SW, i.e., main effects, as well as their interaction as fixed errors in the analysis for the carcass variables as well as the physicochemical variables of the belly, LM, and SM; as for sensory evaluation, the model included the experimental animal (pig) nested within sex \times SW (pig [sex \times S]) and the panelist in addition to the main effects and their interaction. In all analyses, the pig was the experimental unit. The main effects and their interaction, which were tested using the pig (sex \times SW) and the pig as the error terms for the sensory variables and the rest of the variables, respectively, were judged significant when the corresponding p -value was 0.05 or less. Means were compared by a t -test by virtue of the PDIFF option of the SAS program only when the p -value for the main effect or the interaction of the main effects was significant.

RESULTS

Quantitative characteristics of the carcass and its pork belly

The dressing percentage was greater for the Hi and XHi groups than for the Av group, with no difference between Hi and XHi (Table 2). BFT was also greater for the Hi (31.2 mm) and XHi (29.3 mm) groups than for the Av group (25.0 mm). The Av group pigs yielded 11 Grade 1⁺ or 1 carcasses and only one Grade 2, whereas in the Hi and XHi groups, 20 carcasses fell on Grade 2, with four receiving Grade 1⁺ or 1. The weight of the belly, as expected, was greatest for the XHi group and least for the Av group. Moreover, the SW \times sex interaction for this variable was significant, but no difference was detected between the barrow and gilt within any of the three SW

Table 2. Physical characteristics of the carcass and the belly of finishing pigs at different slaughter weights

Item	Av (115 kg)		Hi (125 kg)		XHi (135 kg)		SEM	p -value		
	B (n=6)	G (n=6)	B (n=6)	G (n=6)	B (n=6)	G (n=6)		SW	S	SW \times S
Live wt (kg)	115.5	115.9	123.7	124.0	137.6	132.3	1.9	< 0.01	0.34	0.27
Age at slaughter (d)	177	184	191	198	205	212	0			
Carcass wt (kg)	86.6	86.2	97.6	100.4	106.7	102.0	1.5	< 0.01	0.55	0.07
Dressing (%)	75.1	74.4	78.9	79.4	77.5	77.1	1.0	< 0.01	0.80	0.84
BFT ¹⁾	25.4	24.6	30.9	27.6	31.4	31.0	1.3	< 0.01	0.22	0.59
Number of carcasses by grade										
1+	2	3	0	1	0	0				
1	3	3	2	0	1	0				
2	1	0	4	5	5	6				
Belly										
Wt ²⁾ (kg)	5.10	5.00	5.79	6.21	6.75	6.30	0.16	< 0.01	0.74	0.04
Yield ²⁾³⁾ (%)	11.80	11.61	11.93	12.32	12.66	12.35	0.13	0.01	0.87	0.35
Fat ²⁾⁴⁾ (%)	39.0	36.5	39.7	37.7	38.4	38.4	2.4	0.92	0.45	0.86

¹⁾Backfat thickness; Adjusted for the desired live wt indicated at the column heading.

²⁾Only the primal cut from the left half-carcass was measured.

³⁾100 \times 2 \times weight of the left-side belly/wt of the whole carcass.

⁴⁾100 \times inter-muscular fat area/total area of the cross-section of the belly at the 11th rib.

Av, average; Hi, high; XHi, extra-high; B, barrow; G, gilt; SW, slaughter weight; S, sex; BFT, backfat thickness.

groups. The percent yield of the belly per whole carcass was greater for the XHi group (12.50%) than for the Av group (11.71%), with no difference between the former and Hi group (12.13%). However, the ratio of the area for the inter-muscular fat per total cross-section of the belly at the 11th rib did not differ across the three different SW groups.

Physicochemical characteristics of the muscle

None of the physicochemical properties of LM measured in the present study, including pH, lightness (L^*), redness (a^*), drip loss, cooking loss, Warner-Bratzler shear force, and the content of each of moisture, protein, and fat, differed among the three groups with different SW or between the barrow and gilt (Table 3). The pH value, lightness, redness, and drip loss of SM were also not influenced by the SW or sex. The cooking loss of SM was less for the Hi group vs. Av and XHi groups. The moisture and protein contents of SM were not influenced by the SW or sex. However, fat content of this muscle was greater for the XHi group (2.64%) vs. Av (1.83%) and Hi (2.04%). Moreover, the fat content of SM was correlated with SW ($r = 0.55$; $p < 0.01$).

The percentages of myristic acid (14:0) and palmitic acid (16:0) out of total FA by weight in LM did not differ among the SW groups or between the sexes (Table 4). However, the stearic acid (18:0) percentage of LM was less for the XHi group (12.1%) than for the Av group (13.2%) and was not different between the XHi and Hi (12.7%) groups. Percentages of palmitoleic (16:1), oleic

Table 3. Physicochemical characteristics of the *longissimus dorsi* muscle and *Semimembranosus* muscle of finishing pigs at different slaughter weights¹⁾

Item	Av (115 kg)		Hi (125 kg)		XHi (135 kg)		SEM	p-value		
	B	G	B	G	B	G		SW	S	SW × S
<i>Longissimus dorsi</i> muscle										
pH	5.66	5.63	5.64	5.70	5.66	5.66	0.02	0.45	0.59	0.13
CIE L^*	49.2	50.3	51.1	49.6	48.6	50.1	0.8	0.46	0.56	0.12
CIE a^*	6.38	6.21	5.79	5.53	5.87	5.36	0.34	0.09	0.27	0.88
DL (%)	5.95	5.21	6.49	4.94	5.34	5.48	0.55	0.86	0.12	0.31
CL (%)	23.4	23.7	25.0	23.1	24.4	24.6	0.9	0.60	0.54	0.41
SF (kg/cm ²)	3.99	3.89	3.84	4.22	3.67	3.09	0.38	0.81	0.58	0.82
Chemical composition (%)										
Moisture	73.4	73.7	73.5	73.5	73.8	73.9	0.3	0.62	0.97	1.00
Protein	22.5	22.1	22.9	22.4	21.9	22.7	0.3	0.47	0.90	0.12
Fat	2.19	1.95	1.88	2.22	1.95	1.68	0.28	0.60	0.80	0.47
<i>Semimembranosus</i> muscle										
pH	5.62	5.60	5.55	5.62	5.59	5.60	0.03	0.64	0.42	0.21
CIE L^*	50.9	51.8	53.4	50.9	52.8	53.2	0.9	0.20	0.57	0.12
CIE a^*	8.40	8.25	8.56	8.24	9.27	8.68	0.42	0.25	0.30	0.87
DL (%)	5.81	5.89	6.87	6.03	6.67	6.39	0.40	0.21	0.33	0.56
CL (%)	25.7	26.7	22.1	22.6	26.2	26.3	1.3	< 0.01	0.62	0.95
SF (kg/cm ²)	4.15	3.18	3.18	3.17	3.39	3.33	0.29	0.25	0.15	0.19
Chemical composition (%)										
Moisture	73.6	73.7	73.5	73.5	73.8	73.9	0.3	0.70	0.62	0.74
Protein	22.3	21.8	21.9	21.6	21.6	22.0	0.3	0.65	0.61	0.23
Fat	1.89	1.76	2.40	1.68	2.83	2.45	0.25	< 0.01	0.06	0.51

¹⁾Data are means of six animals in each SW × S combination.

Av, average; Hi, high; XHi, extra-high; B, barrow; G, gilt; SW, slaughter weight; S, sex; DL, drip loss; CL, cooking loss; SF, Warner-Bratzler shear force.

Table 4. Composition of fatty acids of the *longissimus dorsi* muscle and *Semimembranosus* muscle of finishing pigs at different slaughter weights¹⁾

Item	Av (115 kg)		Hi (125 kg)		XHi (135 kg)		SEM	p-value		
	B	G	B	G	B	G		SW	S	SW×S
<i>Longissimus dorsi</i> muscle										
14:0	1.91	1.83	1.69	1.98	1.88	1.82	0.10	0.93	0.53	0.13
16:0	25.9	25.6	24.6	25.9	25.4	25.0	0.6	0.59	0.66	0.26
18:0	13.5	12.9	12.2	13.2	12.2	11.9	0.4	0.05	0.88	0.22
16:1	3.84	3.95	4.12	3.99	3.87	3.98	0.27	0.79	0.82	0.84
18:1	38.6	39.3	39.7	40.2	39.5	40.9	0.9	0.39	0.28	0.90
18:2	9.1	10.2	11.3	9.3	10.9	10.5	1.2	0.68	0.67	0.45
20:4	4.04	3.22	3.49	2.37	3.08	2.75	0.46	0.23	0.06	0.70
Others	3.2	3.0	3.0	3.0	3.2	3.2				
Total	100.0	100.0	100.0	100.0	100.0	100.0				
SFA	41.6	40.7	38.8	41.4	39.8	39.0	0.9	0.16	0.64	0.09
UFA	58.4	59.3	61.2	58.6	60.2	61.0	0.9	0.16	0.68	0.09
n-3	0.42	0.35	0.38	0.48	0.44	0.45	0.04	0.26	0.73	0.10
n-6	13.5	13.8	15.2	12.1	14.4	13.6	1.3	0.94	0.27	0.44
<i>Semimembranosus</i> muscle										
14:0	2.14	2.00	1.68	1.92	1.72	1.71	0.10	< 0.01	0.73	0.20
16:0	24.7	24.8	23.4	24.1	23.8	23.2	0.4	< 0.01	0.86	0.25
18:0	11.5	11.7	11.4	11.2	11.4	10.4	0.4	0.32	0.34	0.37
16:1	3.75	3.96	3.86	3.88	3.53	3.93	0.24	0.81	0.29	0.75
18:1	39.4	41.0	38.4	38.3	37.5	39.0	1.2	0.22	0.34	0.74
18:2	11.9	10.6	13.6	13.2	13.9	13.9	0.8	0.01	0.40	0.72
20:4	2.89	2.56	4.30	3.96	4.40	4.18	0.60	0.03	0.55	0.99
Others	3.7	3.5	3.4	3.4	3.7	3.7				
Total	100.0	100.0	100.0	100.0	100.0	100.0				
SFA	38.7	38.8	36.8	37.5	37.3	35.7	0.7	0.01	0.70	0.26
UFA	61.3	61.2	63.2	62.5	62.7	64.3	0.7	0.01	0.70	0.27
n-3	0.54	0.47	0.52	0.53	0.55	0.56	0.04	0.46	0.62	0.56
n-6	15.3	13.6	18.4	17.7	18.8	18.5	1.4	0.01	0.42	0.86

¹⁾Data, expressed as percentages of total fatty acids by weight, are means of six animals in each SW × S combination.

Av, average; Hi, high; XHi, extra-high; B, barrow; G, gilt; SW, slaughter weight; S, sex; SFA, saturated fatty acids; UFA, unsaturated fatty acids.

(18:1), linoleic (18:2), and arachidonic (20:4) acids did not differ among the three different SW groups or between the sexes. Effects of the SW and sex on percentages of total saturated fatty acids (SFA), total unsaturated fatty acids (UFA), n-3 and n-6 FA were also non-significant.

In SM, the percentage of myristic acid was less for the Hi (1.8%) and XHi (1.7%) groups than for the Av group (2.1%). The palmitic acid percentage of SM was also less for the Hi (23.7%) and XHi (23.5%) groups vs. the Av (24.7%). Conversely, the percentage of linoleic acid was greater for the Hi (13.4%) and XHi (13.9%) groups than for the Av (11.3%); the arachidonic acid percentage was also greater for the Hi (4.1%) and XHi (4.3%) groups vs. Av (2.7%). However, percentages of stearic, palmitoleic, and oleic acids did not differ among the three different SW groups. The percentage of SFA was less for the Hi and XHi groups than for the Av group, whereas the opposite was true for UFA and n-6 FA. The n-3 FA percentage of SM, however, did not differ among the three groups with different SW.

Sensory evaluation

The score for the color for fresh LM did not differ among the groups with different SW or between the sexes (Table 5). The aroma score for fresh LM was less for the Hi (6.69) and XHi (6.67) groups than for the Av group (6.88). The odor score also was less for the Hi (6.74) and XHi (6.68) groups vs. the Av group (6.90). However, scores for the drip loss, marbling, and acceptability for this muscle were not influenced by the SW or sex. The scores for fresh SM did not differ among the three SW groups or between the sexes, except for the odor score, which was less for the XHi group (6.50) than for the Av (6.75) and Hi (6.70) groups. The acceptability score was greater for the Av group than for the XHi group only in gilts and also for the gilt vs. barrow only within the Hi group, with

Table 5. Effects of the slaughter weight of finishing pigs on sensory attributes of their muscles¹⁾

Item	Av (115 kg)		Hi (125 kg)		XHi (135 kg)		SEM	p-value		
	B	G	B	G	B	G		SW	S	SW×S
Fresh muscle										
<i>Longissimus dorsi</i> muscle										
Color	6.60	6.38	6.50	6.83	6.69	6.48	0.17	0.58	0.82	0.19
Aroma	6.93	6.83	6.60	6.79	6.74	6.60	0.09	0.04	0.83	0.14
Odor	6.93	6.88	6.69	6.79	6.62	6.74	0.06	< 0.01	0.23	0.28
Drip loss ²⁾	6.93	6.86	6.81	6.76	6.76	6.71	0.07	0.07	0.31	0.98
Marbling	6.79	6.76	6.76	6.67	6.83	6.60	0.19	0.94	0.45	0.85
Acceptability	6.93	6.71	6.52	6.79	6.74	6.62	0.12	0.36	0.82	0.15
<i>Semimembranosus</i> muscle										
Color	6.48	6.71	6.48	6.67	6.57	6.41	0.16	0.78	0.50	0.39
Aroma	6.62	6.71	6.57	6.81	6.55	6.50	0.08	0.08	0.14	0.19
Odor	6.71	6.79	6.60	6.81	6.45	6.55	0.09	0.02	0.09	0.69
Drip loss	6.43	6.67	6.57	6.86	6.81	6.83	0.11	0.06	0.05	0.47
Marbling	6.71	6.86	6.50	6.76	6.62	6.50	0.15	0.33	0.45	0.45
Acceptability	6.52 ^{ab}	6.83 ^a	6.41 ^b	6.76 ^a	6.57 ^{ab}	6.40 ^b	0.11	0.23	0.07	0.04
Cooked muscle										
<i>Longissimus dorsi</i> muscle										
Color	6.62	6.64	6.86	6.79	6.76	6.86	0.04	< 0.01	0.65	0.16
Aroma	6.74	6.64	6.67	6.69	6.67	6.69	0.05	0.96	0.70	0.41
Flavor	6.93	6.76	6.81	6.74	6.90	6.69	0.09	0.72	0.05	0.72
Juiciness	6.24 ^b	6.33 ^{ab}	6.24 ^b	6.71 ^a	6.76 ^a	6.33 ^{ab}	0.15	0.22	0.70	0.02
Tenderness	6.86	6.83	6.38	6.93	6.83	6.71	0.22	0.68	0.46	0.27
Acceptability	6.60	6.74	6.36	6.81	6.81	6.60	0.16	0.77	0.36	0.15
<i>Semimembranosus</i> muscle										
Color	6.74	6.69	6.67	6.74	6.67	6.71	0.06	0.92	0.63	0.58
Aroma	6.67	6.62	6.60	6.42	6.50	6.62	0.06	0.32	0.39	0.34
Flavor	6.69	6.79	6.81	6.67	6.76	6.79	0.09	0.90	0.91	0.39
Juiciness	6.38	6.33	6.48	6.31	6.40	6.36	0.12	0.95	0.36	0.81
Tenderness	6.48	6.79	6.86	6.79	6.74	6.60	0.16	0.45	0.81	0.32
Acceptability	6.45	6.42	6.76	6.62	6.71	6.62	0.09	0.28	0.84	0.18

¹⁾Each sensory attribute was scored by seven trained panelists according to a 9-point hedonic scale ranging from 1 for the worst/least to 9 for the best/most, with an exception for drip. Data are means of six animals in each SW × S combination.

²⁾Point scores 1 and 9 correspond to the most and least, respectively.

^{ab}Means in a same row with no common superscript differ ($p < 0.05$).

Av, average; Hi, high; XHi, extra-high; B, barrow; G, gilt; SW, slaughter weight; S, sex.

either main effect insignificant.

The color score for cooked LM was greater for the Hi (6.82) and XHi (6.81) groups than for the Av group (6.63). However, neither the SW nor the sex had any significant effect on any of the scores for aroma, flavor, juiciness, tenderness, and acceptability for cooked LM, except for the flavor score, which was greater for the barrow (6.88) than for the gilt (6.73). In addition, the juiciness score was greater for the XHi group than for the Av group only in barrows and also for the gilt vs. barrow only in the Hi group. In cooked SM, none of the scores for the color, aroma, flavor, juiciness, tenderness, and acceptability was affected by the SW or sex.

DISCUSSION

The SW of finishing pigs are determined by various internal and external factors such as the genetic potential of growth performance in the individual pig itself, social and cultural traditions, the needs of consumers and packers, and the grading standards [1,31–33]. For example, finishing pigs in Korea are slaughtered at around 115 kg on average to meet the required range of CW for the top grade, Grade 1⁺, which should be 83 kg or greater but less than 93 kg [25]; this differs with the SW of 160 kg or greater in Italy, where big carcasses are needed to make the dry-cured hams, and the SW range of around 100–140 kg in the U.S., which depends on pork productivity and the demand of the packers [131 kg on average; 1,22,31,32]. It has been reported that the increase of SW results in a decreased production cost per unit weight of pork accompanied by slight increases in the dressing percentage and the yield percentage of the belly although growth rate and feed efficiency decrease following the increase of SW due to increased fat deposition [1,4,6,8,32]. It was therefore the rationale of the present study that if CW could be increased separately from the carcass grading system, the profitability would improve and the flavor of the meat might also improve [12,34], resulting in the improvement of pork quality, as was expected of the carcasses from the Hi and XHi groups of the present study mostly exceeding the 97-kg upper limit of Grade 1.

In this study conducted on non-lean finishing pigs, the BFT was excessive when the SW was greater than the standard (115 kg), while the dressing percentage and the yield percentage of the pork belly slightly increased, which was consistent with published results [1,4,6,8,32]. In addition, the finding of this study that the ratio of inter-muscular fat area in the cross section of pork belly at the 11th rib, where excessive fat - so called 'caky fat' - deposition occurs, was within the normal range regardless of SW, was also consistent with the finding of Park et al. [2] that the fat weight ratios of pork belly slices between the 11th and 12th ribs in 85–150-kg finishing pigs were independent of SW. On the other hand, the increases of redness and marbling of LM due to increased SW detected in a data set of pooled results [8], which were inconsistently observed in the relevant individual studies [4–7], were not detected in the present study.

The FA composition of IMF is an important factor significantly influencing the eating quality of meat [9,13,35,36]. For instance, mono-UFA, especially oleic acid, is known to have a positive influence on eating quality of pork, with SFA and n-3 FA exerting negative effects; however, the increased percentages of UFA, including linoleic acid, arachidonic acid, and n-3 FA, with reduced SFA, in SM did not influence any sensory attribute of cooked meat. These SW-associated changes in FA composition, which were not apparent in LM in the present study, have been observed in LM as well by Ba et al. [34]. Reasons for these differential effects of SW on FA composition in these two studies are not clear at present, but are probably related to accumulation of dietary FA within IMF, which, *de facto*, cannot be separated from *de novo* FA synthesis [12,34]. In this regard, it has been well documented that polyunsaturated fatty acids (PUFA) represented by linoleic acid, a n-6 FA, and n-3 FA such as linolenic acid in the diet are mostly incorporated into the fat depot

instead of being broken down in the body [9,13,36]. Moreover, the finisher diet used for the present study, which contained 2.5% of lard and 7% of corn distillers dried grains with solubles, respectively (personal communication with the manufacturer of the diet), rich in UFA including linoleic acid [37,38], was provided to the Hi and XHi groups longer than to the Av group for about two and four weeks, respectively. Apart from the dietary influence on fat metabolism, the changes in FA composition of IMF due to the increased SW may well be a merit of heavy market pigs in terms of public health, because UFA, especially n-3 FA, lowers the risk of cardiovascular diseases whereas SFA increases the risk [35,39,40].

The aroma and odor scores of fresh LM and the odor score of fresh SM decreased due to an increase in SW, but all of these items showed a normal range of scores and the differences among the experimental groups were minimal. It is known that PUFA such as linoleic acid and n-3 FA are oxidized during the preservation of fresh meat, resulting in the generation of off-odor substances, low sensory odor scores, and low flavor of cooked meat [9,35,41]. In this study, it is assumed that the reason for low odor scores due to the increase of SW was not related to fat rancidity because the percentage of linoleic and n-3 FA in LM and SM was neither high nor correlated with odor score. Considering these results and the lack of differences among the three SW groups in other attributes, it is interpreted that the increase in SW has little to no effect on the overall sensory quality of fresh meat, which was not consistent with the increase of sensory quality of fresh meat due to the increase of SW in lean pigs in previous studies [1,5,6,8].

The BFT and IMF content of finishing pigs, in general, increase with the increase in age or SW [1,11,12,32,34], although consequences of this on eating quality of pork are not consistent between studies [13,33,42,43]. The IMF content of LM in the present study was neither influenced by SW, with an overall average of 2.0%, nor was correlated with the sensory attributes associated with eating quality, which was consistent with the results of Jeong et al. [8] for the lean pigs reared on the low-energy diet with their SW and overall average IMF content being 110–138 kg and 2.6%, respectively. In contrast, Hwang et al. [44] have reported that the IMF content of LM of market pigs increased approximately from 2.1% to 3.0% between their carcass weights below 90 kg and over 100 kg, respectively, which were comparable to those for the Av and XHi groups of the present study, respectively, and that the IMF content was positively correlated with flavor and palatability of cooked LM. Furthermore, Hoa et al. [45] have reported that the IMF content was greater for pigs with their BFT over 20 mm (6.7%) than for those with < 20-mm BFT (4.1%) in market pigs weighing 112 kg on average and was also positively correlated with BFT, flavor, juiciness, and acceptability of cooked LM. Overall, improvement in sensory attributes of LM associated with an increased SW or BFT is apparently dependent on a concomitant increase in IMF in these studies, suggesting a key role for IMF in the eating quality of cooked LM. In a similar context, the differential in the IMF content of SM between the different SW groups in the present study probably was not significant enough to make any difference in sensory attributes.

In conclusion, the excessive back fat deposition due to an increase in SW of non-lean finishing pigs is expected to result in a decrease in production efficiency outweighing the advantages of the slight increases in the dressing percentage and the yield percentage of the pork belly accruing from the increased SW. Although the increase of SW resulted in increases in the IMF content and ratios of a few UFA in SM and a decrease in the ratio of SFA, it had practically little effect on the overall sensory quality of fresh and cooked LM as well as SM. As such, production of non-lean pigs heavier than 115 kg will be disadvantageous economically unless consumers pay a substantial premium for the pork of over-fattened market pigs.

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