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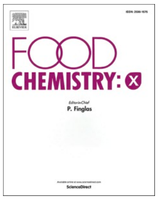

Relationship between the pH of *semispinalis capitis* muscle and the quality properties of pork shoulder butt and belly slices

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ABSTRACT

This study investigated the relationship of carcass characteristics such as hot carcass weight and back fat thickness (BFT) and the pH of *semispinalis capitis* (SC) with the cooking loss (CL) of pork shoulder butt and the CL and Warner–Bratzler shear force (WBSF) of belly. BFT was correlated with the CLs of the butt slices ($r_s = -0.30$) and the belly slices ($r_s = -0.27$ to -0.32). The pH of the SC muscle showed a correlation with the CLs of the butt slices ($r_s = -0.45$) and the belly slices of the 6th and 11th thoracic vertebrae ($r_s = -0.28$ to -0.33). Additionally, the correlations ($r_s = 0.62$ to 0.77) were observed in the CLs among the belly slices. However, the WBSF of the belly slices did not show correlations with others. Therefore, the pH of the SC muscle as well as BFT can be used to obtain information on the CL of shoulder butts and bellies in carcasses.

1. Introduction

The consumption of meat not only provides nutrients, such as high-quality protein, vitamins, and minerals, but also provides pleasure to consumers (Jeong et al., 2024; Lee, Jo, Jeon, et al., 2023; Piazza et al., 2015). Consumer satisfaction demands an improvement in the quality of meat (Ahammad & Kim, 2024; Munezero & Kim, 2023). Additionally, consumer demand for information on meat quality has increased (An et al., 2022; Jo et al., 2024). Among the various quality properties of meat, tenderness and juiciness are important for consumer satisfaction (Aaslyng et al., 2003; ElMasry et al., 2012; Han et al., 2024; Lee et al., 2024).

Pork is the preferred meat of consumers worldwide. In South Korea, pork is the most consumed meat, and the most preferred primary cuts are the shoulder butt and belly because of their highly tender properties (Cho & Kim, 2023; Jo et al., 2022; Kim et al., 2023; Lee et al., 2018). The shoulder butt and belly are composed of various muscle and fat layers, which make them tender (Albano-Gaglio et al., 2024; Font-i-Furnols et al., 2023). However, the muscles that make up the belly and the distribution of fat layers differ among belly slices from different anatomical locations in the whole pork belly (Lee et al., 2018). Therefore, the quality properties of belly slices may differ at different locations in the whole pork belly (Albano-Gaglio et al., 2024; Hoa, Seol, et al., 2021; Lee et al., 2018). Additionally, despite originating from the same carcass, primary cuts can show distinct meat quality due to differences in chemical composition, particularly in the muscle types of various cuts, resulting in different meat properties (Jo et al., 2022; Schumacher et al., 2022).

For providing information on meat quality, the factors related to meat quality can be assessed in the carcass grading process. The carcass properties such as backfat thickness (BFT) and hot carcass weight (HCW) have been used in South Korea to grade pork meat quality and are related to pork fatness (Duziński et al., 2015; Hoa, Seo, et al., 2021). A previous study has reported that the fatness of pork belly is related to its juiciness (Jo et al., 2022). However, controversial results have been reported regarding the effects of HCW on pork quality. Harsh et al. (2017) found that HCW was a factor in the variability of the pork juiciness indicator such as the pH and cooking loss (CL) of pork loin, although no effects of HCW were found on the properties of pork ham. In addition, the BFT of pork carcass showed an effect on the CL of pork loin, but not on the CL of pork ham, and the shear force (SF) as an indicator of the tenderness in both pork cuts was not affected by the BFT (Oh et al., 2022). However, the relationship of BFT and HCW on the quality properties of pork belly and shoulder butt is yet to be reported.

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In addition to predicting meat quality indirectly by BFT and HCW, direct measurement can be more appropriate for obtaining information on meat quality. However, the properties of pork belly cannot be assessed in carcasses because it is not exposed to the outside. *Semispinalis capitis* (SC) muscle is a muscle in the shoulder butt that is exposed to the outside in half of the carcass. We hypothesized that if the properties of the SC muscle are related to the quality of shoulder butt and pork belly, this area can be used for quality prediction.

Therefore, we investigated the relationship of BFT and HCW with the CL of the shoulder butt and the CL and SF of belly slices as an indicator of the juiciness and tenderness, respectively, from different anatomical locations. In addition, the relationship between the pH of the SC muscle and the quality properties of the shoulder butt and belly slices, and the relationship between the quality properties of the shoulder butt and belly slices were investigated.

2. Materials and methods

2.1. Pork belly and shoulder butt preparation

Shoulder butts and whole pork bellies from 120 gilt carcasses (Landrace x Yorkshire x Duroc) were used in this study. This study was conducted in a total of 30 batches with 7 days interval (four carcasses per batch). Pork shoulder butts cut from the 1st cervical vertebra to between the 4th and 5th thoracic vertebrae (TV) and non-trimmed whole belly from between the 4th and 5th TV to the 6th lumbar vertebrae (LV) were obtained from the right half of the carcasses at 24 h postmortem. The pork shoulder butt was sliced into two pieces, each 2 cm thick, from the capitulum, and the SC muscle was separated from the remaining part. Three pork belly pieces were sliced (7 mm thickness) at the following positions: 6th TV, 11th TV, and 4th LV, using a slicer (HS-2NA, FuJee, Hwaseong, Korea). The analysis of pork CL and SF was performed on the day of collection of pork samples.

BFT (mm) and HCW (kg) were measured according to the pork carcass grading procedures of the Korea Institute for Animal Products Quality Evaluation. The HCW values were measured automatically during the slaughter process. The BFT was measured manually at two sites, between the 11th and 12th TV and between the last TV and the first LV, and the mean values of the two sites were used (Hoa, Seol, et al., 2021).

2.2. Meat quality measurements

In order to measure the pH of the SC muscle, 1 g of muscle sample was homogenized with distilled water (9 mL) using a homogenizer (T25 basic, IKA Gmbh & CO. KG, Germany) at 12,000 rpm for 30 s (Lee, Jo, Jeong, et al., 2023). The mixture was centrifuged (ScanSpeed 1580R, LabogeneAPS, Lillerød, Denmark) at 2265 x g for 10 min. The supernatants were filtered using a Whatman No. 4 filter paper (Whatman Inc., England). The pH of the filtrate was measured using a pH meter

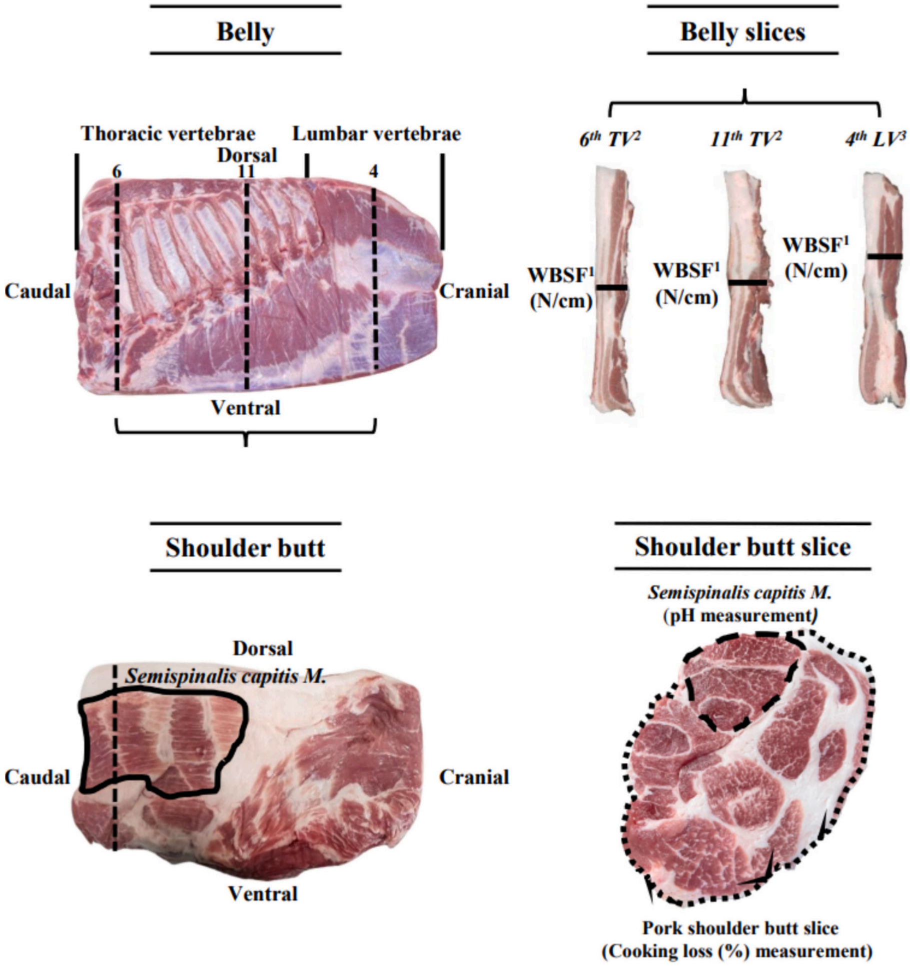

Fig. 1. Images of whole pork belly, shoulder butt, and belly slices obtained from different locations in this study.

[1] Warner–Bratzler shear force (N/cm).

[2] Thoracic vertebrae.

[3] Lumbar vertebrae.

(SevenDirect SD20, Mettler-Toledo Inti Inc., Schwerzenbach, Switzerland) after calibration with the standard buffer solutions of pH 4 and pH 7.

The CL of pork samples was measured by the methods of Jo et al. (2023). The slices of pork shoulder butt and bellies were cooked for 40 min in a water bath (DS-250WM, Daewon Science Inc., Bucheon, Korea) at 80 °C, to ensure an internal temperature of 80 °C after vacuum packaging. After cooling at room temperature (25 °C) for 30 min, the cooked pork butt and belly slices were removed from vacuum packaging, the surface moisture of the sliced pork meat was removed using paper towels, and the cooked pork slices were weighed. The CL was calculated as follows: [(Weight of raw meat-Weight of cooked meat)/Weight of raw meat] x 100.

The Warner–Bratzler shear force (WBSF) of the cooked belly slices was measured at the positions shown in Fig. 1 based on the method of Han et al. (2024). The belly slice was sheared using a blade set (HDP/WBV, Stable Micro Systems Ltd., UK) mounted on a texture analyzer (TA.XT plus, Stable Micro Systems Ltd) at a test speed of 2 mm/s. The position for measuring the WBSF of the belly slices was determined as the position with the most number of muscle layers. The shear force was divided by the cut surface width (cm) to correct for differences in the belly widths (Fig. 1).

2.3. Statistical analysis

Statistical analyses were performed using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA). The univariate procedure was used to test the normality of the data, which was determined using the Shapiro–Wilk ($p > 0.05$) test. Spearman rank correlation was used to investigate the relationship between the properties of the pork belly and shoulder butt and the carcass information because of the non-normal distribution of the data (CL of shoulder butt, pH of SC muscle, WBSF of belly at the 6th TV and 4th LV, HCW, and BFT). The interpretation of correlation strength followed the classification by Schober et al. (2018): a negligible correlation (r_s = 0.00–0.10), a weak correlation (r_s = 0.10–0.39), a moderate correlation (r_s = 0.40–0.69), a strong correlation (r_s = 0.70–0.89), and a very strong correlation (r_s = 0.90–1.00). A mixed model was used for the statistical analysis of the differences in meat quality (WBSF and CL) among belly slices, and the significance of the main effects was determined using Tukey's multiple comparison tests ($p < 0.05$). Table 1 presents the descriptive statistics of the quality properties measured in this study.

Table 1
Descriptive statistics for pork.

	Mean	SD[2]	Minimum	Maximum
Cooking loss (%)				
Belly_6th Thoracic vertebrae	22.259	2.937	15.490	28.340
Belly_11th Thoracic vertebrae	21.141	2.996	14.060	28.270
Belly_4th Lumbar vertebrae	21.984	2.789	14.790	28.870
Shoulder butt	19.417	3.155	14.180	30.670
pH				
Butt_ *Semispinalis capitis* M.	6.361	0.295	5.800	6.980
WBSF (N/cm)[1]				
Belly_6th Thoracic vertebrae	3.367	0.623	1.850	4.970
Belly_11th Thoracic vertebrae	3.710	0.827	1.970	7.090
Belly_4th Lumbar vertebrae	6.212	1.542	3.150	9.890
Carcass information				
Hot carcass weight (HCW) (kg)	87.807	2.684	83.000	92.000
Back fat thickness (BFT) (mm)	19.974	2.093	17.000	24.000

Pork shoulder butt and belly slices were collected from 120 pork carcasses.

[1] Warner–Bratzler shear force.

[2] Standarad deviation.

3. Results and discussion

3.1. Relationship between quality properties of pork shoulder butt and carcass characteristics

Previous study has reported that the effect of HCW on pork quality differs by pork cuts (Harsh et al., 2017). In this study, the HCW had no correlations with the pH of the SC muscle or the CL of the shoulder butt slice (Table 2). However, the BFT as a carcass characteristic showed a weak positive and negative correlation with the pH of the SC muscle (r_s = 0.26) and CL of the shoulder butt slice ($r_s = -0.30$), respectively. This result may be attributed to the positive correlation between BFT and pork fatness (Duziński et al., 2015; Hoa, Seo, et al., 2021; Uttaro & Zawadski, 2010). A previous study reported that the fat content had a positive correlation ($r = 0.32$) with the pH of pork loins (Watanabe et al., 2018). The pork shoulder butt slices used in this study comprised various muscles and intermuscular fats (Fig. 1). The increase in the fat content of meat consisting of various muscles and fat layers might indicate a relative decrease in the muscle containing water (Jo et al., 2022). The fluid exuded from meat during cooking is mainly water (Jo et al., 2022). Therefore, the CL of pork butts could decrease with an increase in fat content because of the low water content.

The pH of SC muscle showed a moderate negative correlation ($r_s = -0.45$) with the CL of butt slice. CL is mainly affected by the water-holding capacity of meat (Aaslyng et al., 2003). The pH is an important factor affecting the water-holding capacity of meat (Jung et al., 2015). Water in meat exists in three forms: 1) bound water, 2) immobilized water, and 3) free water. Increasing the ratio of bound or immobilized water is important for improving the water-holding capacity of meat (Pearce et al., 2011). The isoelectric point of myofibrillar proteins such as myosin and actin is pH 5.2–5.3. An increase in muscle pH indicates an increased repulsive force between myofibrillar proteins, resulting in an increase in space for capturing water within myofibrils (Huff-Lonergan & Lonergan, 2005). Therefore, the ratio of immobilized water within the myofibrils could be increased, leading to an increase in the water-holding capacity and a reduction in CL.

The correlation coefficient between the pH of the SC muscle and the CL of the butt slice was higher than that between the carcass characteristics, such as HCW and BFT, and the CL of the butt slice, even though the SC muscle is one of the various muscles that compose the butt slice (Fig. 1). Meat quality can be affected by physicochemical changes that occur during the conversion of muscle to meat after slaughter. Jo et al. (2022) suggested that the influences of internal and external factors on the postmortem physicochemical changes can be similar in the muscles of primal cuts of carcasses, despite the differences in their characteristics, particularly in muscle fiber types and muscle contents such as water, protein, fat, and glycogen. Therefore, the pH of the SC muscle had a correlation with the CL of the butt slice composed of various muscles and intermuscular fat. Based on these results, we may determine the potential of using the SC muscle as a prediction site for the meat quality of pork shoulder butts.

Table 2
Correlation coefficients (r_s) for quality properties of pork shoulder butt.

	HCW[1]	BFT[2]	pH[3]	CL[4]
HCW[1]	1	–	–	–
BFT[2]	0.15	1	–	–
pH[3]	0.04	0.26**	1	–
CL[4]	0.07	−0.30**	−0.45***	1

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

Pork shoulder butt and was collected from 120 pork carcasses.

[1] Hot carcass weight (kg).

[2] Back fat thickness (mm).

[3] pH of *Semispinalis capitis* M.

[4] Cooking loss (%) of pork shoulder butt.

3.2. Relationship between quality properties of pork belly and carcass characteristics

For this study, the belly slices were categorized into three groups (5th -10th TV, 10th–14th TV, and 1st-6th LV) based on the fatness and the distributions of fat layers reported by Lee et al. (2018) and the Animal muscle atlas (2024) (Korea Institute for Animal Products Quality Evaluation). The belly slices at 6th TV, 10th TV, and 4th LV were considered as the representative sample for each group. The pork belly slices had different quality properties, such as CL and WBSF, depending on their anatomical locations (Table S1). The belly slice from the 11th TV had the lowest CL compared to those from the 6th TV and 4th LV ($p < 0.05$). The highest WBSF was found in the belly slice from the 4th LV ($p < 0.05$). According to their anatomical locations, pork belly slices have different fat and muscle proportions, resulting in different quality properties, such as juiciness and tenderness (Lee et al., 2018). A previous study reported that the major factor in the CL of belly slices was fat proportion because an increase in fat proportion decreased the relative muscle proportion containing water (Jo et al., 2022). The belly slice from the 11th TV was composed of more fat layers than those from the 6th TV and 4th LV (Lee et al., 2018). Therefore, the CL was the lowest in the belly slice from the 11th TV. Additionally, the muscle composition of belly slices varies depending on their anatomical location. The belly slice from the 6th TV contained the cranial dorsal serrate muscle, *latissimus dorsi* muscle, and cutaneous muscle of the trunk, while the belly slice from the 11th TV contained the cutaneous muscle of the trunk, transverse thoracic muscle, and external abdominal oblique muscle. The belly slice from the 4th LV contained the external and internal abdominal oblique muscles. The WBSF of these muscles might vary according to the different anatomical locations of the pork belly. Lee et al. (2018) reported that the pork belly in the TV region had a higher fat volume than the LV region. Thus, low intermuscular fat and high muscle portions could increase the WBSF of the belly slice from the 4th LV.

Moderate or strong positive correlations ($r_s = 0.62–0.77$, $p < 0.001$) were observed among the CL of belly slices from different anatomical locations (Table 3). Despite the different muscles and proportions of belly slices described above, there was a close relationship among their CLs. Therefore, the juiciness of belly slices across the carcass could be related despite the differences in anatomical location because the muscles in the carcass might undergo similar physicochemical changes before and after slaughter. The BFT of the carcass showed a negative correlation with the CL of the belly slices, although the correlation strength was weak ($r_s = -0.27 \sim -0.32$). This result was similar to that obtained for pork shoulder butts. Hoa, Seol, et al. (2021) discovered that BFT was negatively correlated ($r = -0.53$) with the total lean meat yield of pork carcasses. Therefore, the proportion of lean muscle in pork belly may be affected by an increase in carcass fatness. Most of the water in pork is trapped within the myofibrils of the muscle (Aaslyng et al., 2003). Therefore, decreased muscle proportion due to increased fatness leads to decreased water content, resulting in a negative correlation between CL and BFT. Jo et al. (2022) found a similar result, in which decreased protein content was accompanied by reduced moisture content in meat, leading to a negative correlation between CL and BFT.

The CL and WBSF of the belly slice from the 11th TV were positively correlated ($r_s = 0.25$, $p < 0.01$). However, belly slices from the 6th TV and 4th LV did not show a correlation between CL and WBSF. A previous study reported that the relationship between the CL and WBSF of meat varied with the muscles, particularly muscle fiber types, because the CL increased with longer heating times and higher temperatures, whereas the WBSF fluctuated, reflecting variable heat-induced changes in muscle fiber shrinkage and strength (Kim et al., 2022; Vaskoska et al., 2021). Additionally, in this study, the WBSF of each belly slice was measured at the position having the highest muscle proportion, whereas the CL was measured for the whole belly slice. Therefore, the correlation between CL and WBSF was inconsistent among belly slices from different anatomical locations. Furthermore, the correlation between the BFT and WBSF of the belly slices was inconsistent.

There was a moderate correlation ($r_s = 0.42$, $p < 0.001$) between the WBSF of the belly slices from the 6th and 11th TV. However, the WBSF of the belly slice from the 4th LV showed no correlation with the WBSF of the belly slice from the 6th and 11th TV. This result might be attributed to the differences in the configuration similarity of the belly slices. The arrangement of fat and muscle layers was relatively similar between the belly slices in the TV and LV regions (Fig. 1). Lee et al. (2018) also observed differences in the quality properties of belly slices between the TV and LV regions.

3.3. Relationship between quality properties of pork belly and shoulder butt

The CL of the butt slice had positive correlations ($r_s = 0.23–0.29$) with the CL of the belly slices from the 6th TV, 11th TV, and 4th LV (Table 4). A previous study found correlations between the quality properties of pork belly and loins, such as pH and proximate composition (Jo et al., 2022). However, the authors reported no correlation between the CL of pork belly and loin (Jo et al., 2022). Knecht et al. (2018) also reported no correlation between the CL of the belly and loin. Meat quality is influenced by physicochemical changes caused by internal and external factors in the muscles before and after slaughter. Although muscle properties differ among primary cuts of pork, internal and external factors during the breeding of pigs and in pork carcasses can affect all muscles. Therefore, the quality properties of primal cuts are correlated (Jo et al., 2022; Knecht et al., 2018). However, the lack of correlation between the CL of pork belly and the loin was due to the different factors influencing their CL; the effect of fat content was significant in the belly but not in the loin (Jo et al., 2022). Both pork belly

Table 3
Correlation coefficients for quality properties of pork belly.

	CL 6th TV[31]	CL 11th TV	CL 4th LV	WBSF 6th TV[2]	WBSF 11th TV	WBSF 4th LV	HCW[3]	BFT[4]
CL 6th TV[1]	1	–	–	–	–	–	–	–
CL 11th TV	0.77***	1	–	–	–	–	–	–
CL 4th LV	0.65***	0.62***	1	–	–	–	–	–
WBSF 6th TV[2]	0.16	0.09	0.15	1	–	–	–	–
WBSF 11th TV	0.27**	0.25**	0.21*	0.42***	1	–	–	–
WBSF 4th LV	−0.01	0.08	−0.09	0.10	0.08	1	–	–
HCW[3]	0.01	0.01	0.08	−0.01	−0.06	−0.06	1	–
BFT[4]	−0.32***	−0.28**	−0.27**	−0.04	−0.22*	−0.07	0.15	1

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.
Pork belly slices were collected from 120 pork carcasses.

[1] Cooking loss (%) of pork belly at 6th and 11th thoracic vertebrae, and 4th lumbar vertebrae.

[2] Warner–Bratzler shear force (N/cm) of pork belly at 6th and 11th thoracic vertebrae, and 4th lumbar vertebrae.

[3] Hot carcass weight (kg).

[4] Back fat thickness (mm).

Table 4
Correlation coefficients for quality properties of pork belly and shoulder butt.

	Shoulder butt	
Belly	pH[1]	CL[2]
CL 6th TV[3]	−0.28**	0.29**
CL 11th TV	−0.33***	0.23*
CL 4th LV	−0.09	0.21*
WBSF 6th TV[4]	−0.09	−0.05
WBSF 11th TV	−0.25**	0.13
WBSF 4th LV	−0.04	−0.12

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

[1] pH of *Semispinalis capitis* M.

[2] Cooking loss (%) of pork shoulder butt.

[3] Cooking loss (%) of pork belly at 6th and 11th thoracic vertebrae, and 4th lumbar vertebrae.

[4] Warner–Bratzler shear force (N/cm) of pork belly at 6th and 11th thoracic vertebrae, and 4th.

and shoulder butt are composed of various muscle and intermuscular fat layers. Therefore, the CL of pork belly and shoulder butt might be correlated because of their compositional similarity. Additionally, the pH of the SC muscle showed negative correlations ($r_s = -0.28$ and −0.33) with the CL of the belly slices from the 6th and 11th TV. Jo et al. (2022) reported that pH was a significant factor affecting the CL of both pork belly and loins. Pork pH is determined by the degree of postmortem glycolysis (Jeong et al., 2023). Although glycolytic capacity can differ among muscles because of differences in glycogen content and activity of glycolytic enzymes, the degree of glycolysis in all muscles can be affected by external stresses before slaughter in animals and postmortem handling in carcasses. Therefore, the pH of the SC muscle in the shoulder butt was correlated with the CL of the belly slices.

Except for the correlation between the pH of the SC muscle and the WBSF of the belly slice from the 11th TV, the pH of the SC muscle and the CL of the shoulder butt slice had no correlations with the WBSF of belly slices. From these results, the pH of the SC muscle can be an indicator of the CL of the shoulder butt and belly but not of the WBSF of belly slices.

4. Conclusion

Between the shoulder butt and belly (different primal cuts), the CL was weakly correlated. Additionally, moderate and strong correlations among the CL of belly slices were found, although the belly slices from different anatomical locations varied in the configurational properties of muscles and intermuscular fat layers. The BFT, as a carcass characteristic, had weak correlations with the CL of the shoulder butt and belly slices, whereas HCW showed no correlation. The pH of SC muscle showed a moderate correlation with the CL of the shoulder butt slices and a weak correlation with the CL of the belly slices. Therefore, the properties of the SC muscle may be used to obtain information on the quality properties of pork in carcasses, along with BFT. However, further studies on the relationships among the quality properties of various primal cuts and the development of suitable techniques for measuring the properties of SC muscle in slaughterhouse conditions are needed.

CRediT authorship contribution statement

Seul-Ki-Chan Jeong: Writing – original draft, Formal analysis, Data curation. **Kyung Jo:** Formal analysis. **Seonmin Lee:** Formal analysis. **Hayeon Jeon:** Formal analysis. **Soeun Kim:** Formal analysis. **Seokhee Han:** Formal analysis. **Minkyung Woo:** Formal analysis. **Hyeun Bum Kim:** Formal analysis. **Pil Nam Seong:** Formal analysis. **Samooel Jung:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fochx.2024.101704.

References

Aaslyng, M. D., Bejerholm, C., Ertbjerg, P., Bertram, H. C., & Andersen, H. J. (2003). Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure. *Food Quality and Preference, 14*(4), 277–288. https://doi.org/10.1016/S0950-3293(02)00086-1

Ahammad, G. S., & Kim, I. H. (2024). Efficacy of decreasing levels of tryptophan relative to lysine on the performance and meat quality of finishing pigs. *Korean Journal of Agricultural Science, 51*(1), 1–8. https://doi.org/10.7744/kjoas.510101

Albano-Gaglio, M., Zomeño, C., Tejeda, J. F., Brun, A., Gispert, M., Marcos, B., & Font-i-Furnols, M. (2024). Pork belly quality variation and its association with fatness level. *Meat Science, 213*, Article 109482. https://doi.org/10.1016/j.meatsci.2024.109482

An, J., Li, Y., Zhang, C., & Zhang, D. (2022). Rapid nondestructive prediction of multiple quality attributes for different commercial meat cut types using optical system. *Food Science of Animal Resources, 42*(4), 655–671. https://doi.org/10.5851/kosfa.2022.e28

Animal muscle atlas. (2024). *Korea institute for animal products quality evaluation*. https://www.ekapepia.com/contents/cont.do.

Cho, H. G., & Kim, H. Y. (2023). Effects of mustard seed extract on physicochemical and storage characteristics of dry-aged pork loin ham. *Food Science of Animal Resources, 43*(6), 961–974. https://doi.org/10.5851/kosfa.2023.e50

Duziński, K., Lisiak, D., Knecht, D., & Środoń, S. (2015). The estimation of pork carcass prima cuts value based on backfat thickness. *Journal of Central European Agriculture, 16*, 112–121. https://doi.org/10.5513/jcea.v16i1.3491

ElMasry, G., Barbin, D. F., Sun, D. W., & Allen, P. (2012). Meat quality evaluation by hyperspectral imaging technique: An overview. *Critical Reviews in Food Science and Nutrition, 52*(8), 689–711. https://doi.org/10.1080/10408398.2010.507908

Font-i-Furnols, M., Albano-Gaglio, M., Brun, A., Tejeda, J. F., Gispert, M., Marcos, B., & Zomeño, C. (2023). The effect of immunocastration of male and female duroc pigs on the morphological, mechanical and compositional characteristics of pork belly. *Meat Science, 204*, Article 109263. https://doi.org/10.1016/j.meatsci.2023.109263

Han, S., Jo, K., Jeong, S. K. C., Jeon, H., Kim, S., Woo, M., Jung, S., & Lee, S. (2024). Comparative study on the postmortem proteolysis and shear force during aging of pork and beef semitendinosus muscles. *Food Science of Animal Resources*. https://doi.org/10.5851/kosfa.2024.e37

Harsh, B. N., Arkfeld, E. K., Mohrhauser, D. A., King, D. A., Wheeler, T. L., Dilger, A. C., … Bolor, D. D. (2017). Effect of hot carcass weight on loin, ham, and belly quality from pigs sourced from a commercial processing facility. *Journal of Animal Science, 95*, 4958–4970. https://doi.org/10.2527/jas2017.1674

Hoa, V. B., Seo, H. W., Seong, P. N., Cho, S. H., Kang, S. M., Kim, Y. S., Moon, S. S., Choi, Y. M., Kim, J. H., & Seol, K. H. (2021). Back-fat thickness as a primary index reflecting the yield and overall acceptance of pork meat. *Animal Science Journal, 92*(1), Article e13515. https://doi.org/10.1111/asj.13515

Hoa, V. B., Seol, K., Seo, H., Kang, S., Kim, Y., Seong, P., Moon, S., Kim, J., & Cho, S. (2021). Investigation of physicochemical and sensory quality differences in pork belly and shoulder butt cuts with different quality grades. *Food Science of Animal Resources, 41*(2), 224–236. https://doi.org/10.5851/kosfa.2020.e91

Huff-Lonergan, E., & Lonergan, S. M. (2005). Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes. *Meat Science, 71*(1), 194–204. https://doi.org/10.1016/j.meatsci.2005.04.022

Jeong, H. G., Jo, K., Lee, S., Yong, H. I., Choi, Y. S., & Jung, S. (2023). Characteristics of pork emulsion gel manufactured with hot-boned pork and winter mushroom powder without phosphate. *Meat Science, 197*, Article 109070. https://doi.org/10.1016/j.meatsci.2022.109070

Jeong, J. W., Lee, S. Y., Kim, J. H., Yun, S. H., Lee, J., Mariano, E., Jr., Moon, S. S., & Hur, S. J. (2024). Analytical methods and effects of bioactive peptides derived from animal products: A mini-review. *Food Science of Animal Resources, 44*(3), 533–550. https://doi.org/10.5851/kosfa.2024.e31

Jo, K., Lee, S., Jeong, H. G., Lee, D. H., Kim, H. B., Seol, K. H., Kang, S. M., & Jung, S. (2022). Prediction of cooking loss of pork belly using quality properties of pork loin. *Meat Science, 194*, 108957. https://doi.org/10.1016/j.meatsci.2022.108957

Jo, K., Lee, S., Jeong, H. G., Lee, D. H., Yoon, S., Chung, Y., & Jung, S. (2023). Utilization of electrical conductivity to improve prediction accuracy of cooking loss of pork loin. *Food Science of Animal Resources, 43*(1), 113–123. https://doi.org/10.5851/kosfa.2022.e64

Jo, K., Lee, S., Jeong, S. K. C., Lee, D. H., Jeon, H., & Jung, S. (2024). Hyperspectral imaging-based assessment of fresh meat quality: Progress and applications. *Microchemical Journal, 197*, Article 109785. https://doi.org/10.1016/j.microc.2023.109785

Jung, S., Kim, H. J., Lee, H. J., Seo, D. W., Lee, J. H., Park, H. B., Jo, C., & Nam, K. C. (2015). Comparison of pH, water holding capacity and color among meats from Korean native chickens. *Korean Journal of Poultry Science, 42*(2), 101–108. https://doi.org/10.5536/KJPS.2015.42.2.101

Kim, S., Choi, J., Kim, E. S., Keum, G. B., Doo, H., Kwak, J., … Lee, N. R. (2023). Evaluation of the correlation between the muscle fat ratio of pork belly and pork shoulder butt using computed tomography scan. *Korean Journal of Agricultural Science, 50*(4), 809–815. https://doi.org/10.7744/kjoas.500418

Kim, S. S., Lee, Y. E., Kim, C. H., Min, J. S., Yim, D. G., & Jo, C. (2022). Determining the optimal cooking time for cooking loss, shear force, and off-odor reduction of pork large intestines. *Food Science of Animal Resources, 42*(2), 332–340. https://doi.org/10.5851/kosfa.2022.e6

Knecht, D., Duziński, K., & Jankowska-Mąkosa, A. (2018). Pork ham and belly quality can be estimated from loin quality measurements? *Meat Science, 145*, 144–149. https://doi.org/10.1016/j.meatsci.2018.06.025

Lee, E. A., Kang, J. H., Cheong, J. H., Koh, K. C., Jeon, W. M., Choe, J. H., … Kim, J. M. (2018). Evaluation of whole pork belly qualitative and quantitative properties using selective belly muscle parameters. *Meat Science, 137*, 92–97. https://doi.org/10.1016/j.meatsci.2017.11.012

Lee, S., Jo, K., Jeon, H., Choi, Y. S., & Jung, S. (2023). Recent strategies for improving the quality of meat products. *Journal of Animal Science and Technology, 65*(5), 895–911. https://doi.org/10.5187/jast.2023.e94

Lee, S., Jo, K., Jeong, H. G., Jeong, S. K. C., Park, J. I., Yong, H. I., Choi, Y. S., & Jung, S. (2023). Higher protein digestibility of chicken thigh than breast muscle in an *in vitro* elderly digestion model. *Food Science of Animal Resources, 43*(2), 305–318. https://doi.org/10.5851/kosfa.2022.e77

Lee, S., Jo, K., Jeong, S. K. C., Jeon, H., Choi, Y. S., & Jung, S. (2024). Characterization of peptides released from frozen-then-aged beef after digestion in an in vitro infant gastrointestinal model. *Meat Science, 212*, Article 109468. https://doi.org/10.1016/j.meatsci.2024.109468. Article 109468

Munezero, O., & Kim, I. H. (2023). Effects of glycozyme addition on fatty acid and meat quality characteristics of growing pigs. *Korean Journal of Agricultural Science, 50*(2), 337–346. https://doi.org/10.7744/kjoas.20230024

Oh, S. H., Lee, C. Y., Song, D. H., Kim, H. W., Jin, S. K., & Song, Y. M. (2022). Effects of the slaughter weight of non-lean finishing pigs on their carcass characteristics and meat quality. *Journal of Animal Science and Technology, 64*(2), 353–364. https://doi.org/10.5187/jast.2022.e18

Pearce, K. L., Rosenvold, K., Andersen, H. J., & Hopkins, D. L. (2011). Water distribution and mobility in meat during the conversion of muscle to meat and ageing and the impacts on fresh meat quality attributes—a review. *Meat Science, 89*(2), 111–124. https://doi.org/10.1016/j.meatsci.2011.04.007

Piazza, J., Ruby, M. B., Loughnan, S., Luong, M., Kulik, J., Watkins, H. M., & Seigerman, M. (2015). Rationalizing meat consumption. The 4Ns. *Appetite, 91*, 114–128. https://doi.org/10.1016/j.appet.2015.04.011

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: Appropriate use and interpretation. *Anesthesia & Analgesia, 126*(5), 1763–1768, 10.1213/ANE.0000000000002864.

Schumacher, M., DelCurto-Wyffels, H., Thomson, J., & Boles, J. (2022). Fat deposition and fat effects on meat quality—A review. *Animals, 12*(12), 1550–1566. https://doi.org/10.3390/ani12121550

Uttaro, B., & Zawadski, S. (2010). Prediction of pork belly fatness from the intact primal cut. *Food Control, 21*(10), 1394–1401. https://doi.org/10.1016/j.foodcont.2010.03.012

Vaskoska, R., Ha, M., Ong, L., Chen, G., White, J., Gras, S., & Warner, R. (2021). Myosin sensitivity to thermal denaturation explains differences in water loss and shrinkage during cooking in muscles of distinct fibre types. *Meat Science, 179*, Article 108521. https://doi.org/10.1016/j.meatsci.2021.108521

Watanabe, G., Motoyama, M., Nakajima, I., & Sasaki, K. (2018). Relationship between water-holding capacity and intramuscular fat content in Japanese commercial pork loin. *Asian-Australasian Journal of Animal Sciences, 31*(6), 914–918. https://doi.org/10.5713/ajas.17.0640