Correlation comparisons among early postmortem loin quality and aged loin and pork chop quality characteristics between finishing pigs from either Duroc or Pietrain sires

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ABSTRACT: Today, the United States exports 2.2 million tons of pork and pork products annually, representing just over 26% of U.S. pork production. In order to meet specific demands of a growing export market, pork quality and carcass characteristics are now integrated into breeding objectives. Color and marbling are 2 loin quality traits that influence consumer acceptability of pork and while correlations between early and aged ventral quality have been established, it is unclear if those correlations differ between production objectives (meat quality vs. lean growth). Therefore, the objective of this experiment was to compare correlations among early postmortem ventral loin quality characteristics and aged ventral loin and chop quality characteristics between pigs sired by either Pietrain (lean growth) or Duroc (meat quality) boars. Early postmortem (~1 d) quality traits included: instrumental and visual color, marbling and firmness, and loin pH on the ventral surface of the loin. Loins were aged until 14 d postmortem in vacuum packages. Aged quality traits included traits evaluated early as well as Warner-Bratzler shear force (**WBSF**) and cook loss. Correlations were compared between Pietrain and Duroc-sired pigs using a Fisher's z-test. Early instrumental lightness (**L***) was moderately correlated with aged ventral L* (Pietrain r = 0.47; Duroc r = 0.65) and aged ventral visual color (Pietrain r = 0.42; Duroc r = 0.58). Early ventral visual color was moderately correlated with aged chop L* (Pietrain r = 0.46; Duroc r = 0.60) and aged chop visual color (Pietrain r = 0.45; Duroc r = 0.57). Early visual marbling was strongly correlated (Pietrain r = 0.68; Duroc r = 0.84) with aged chop visual marbling. Within the Duroc-sired pigs, early L* was moderately correlated with aged chop L* (r = 0.64) but only weakly correlated (r = 0.35) within the Pietrain-sired pigs and those correlations differed at $P \leq 0.02$. Within the Duroc-sired pigs, early ventral visual color was moderately correlated with aged pH (r = 0.44) and aged ventral L* (r = 0.57) but only weakly correlated ($r \leq 0.29$) within the Pietrain-sired pigs and those correlations differed at $P \leq 0.03$. No early postmortem quality traits were correlated ($|r| \leq 0.34$) with WBSF or cook loss for either sire line. In summary, correlations between early and aged postmortem quality traits rarely differed between Duroc- and Pietrain-sired pigs. It is not necessary to account for sire line when relating early and aged quality characteristics.

Key words: correlation, genotype, loin quality, pork, quality, sire line

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INTRODUCTION

Pork is the most consumed animal protein in the world and exported from the United States to countries such as Mexico, Japan, and China (U.S.

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Meat Export Federation [USMEF], 2017). As of the end of 2017, the United States exported 2.45 million metric tons of pork and pork-related products annually, which represents just over 26% of U.S. pork production. Mexico and Japan represent 2 of the top markets for U.S. pork in 2017. Mexico imported the largest amount of pork (801,887 metric tons; $1.5 billion), but Japan was the largest importer on a value basis (393,648 metric tons; $1.6 billion—USMEF, 2017). Japanese importers rank eating quality as the second most important quality attribute (Murphy et al., 2015), but Mexican importers prefer a leaner product (Ngapo et al., 2018). Due to consumer differences in final product demands (color and marbling vs. leanness), sophisticated breeding objectives are used in order to meet specific demands of a growing export market (Miar et al., 2014). Duroc-based breeds are often used to meet the needs of a quality-focused market (National Pork Producers Council [NPPC], 1995), whereas Pietrain-based breeds are fast-growing lean pigs commonly used to satisfy the demand of a lean-focused market (Edwards et al., 2003).

Even in lean-based export markets, eating quality of pork is important. Color and marbling are 2 loin quality traits believed to influence the palatability of pork (Huff-Lonergan et al., 2002). Because the cut surface of a boneless pork loin is not exposed during the fabrication process (early postmortem), packers use the ventral surface of loins during color and marbling evaluation to determine early postmortem pork quality. Recently, it was reported that correlations between early ventral quality and aged quality exist (Harsh et al., 2018); however, it is unclear if those correlations differ between pigs selected for lean growth compared with those selected for meat quality. Therefore, the objective of this study was to compare correlations among early postmortem loin quality characteristics and aged loin and chop quality characteristics between pigs sired by either Pietrain or Duroc boars.

MATERIALS AND METHODS

The Institutional Animal Care and Use Committee at the University of Illinois reviewed and approved the protocol for this experiment.

Pig Background

Pigs (320 total) were sourced from 2 distinct sire lines: 160 barrows and gilts were Pietrain-sired pigs and 160 barrows and gilts were Duroc-sired pigs (Choice Genetics, West Des Moines, IA). Pietrain and Duroc boars were mated with Camborough (Pig Improvement Company, Hendersonville, TN) sows and parity was balanced among sire lines. Pigs were housed in pens of 4 pigs per pen (all from the same sire line) with all pigs within a pen of the same sex. A total of 80 pens of pigs were used in the experiment with 40 pens used in each of 2 blocks. A block was defined as a farrowing group. Pigs from block 1 were 2 wk older than pigs in block 2. The Pietrain-sired pigs were classified as the lean growth line and the Duroc-sired pigs were classified as the meat quality line. Pigs were raised at the University of Illinois Swine Research Center and fed the same diet that met or exceeded nutrient requirements for growing-finishing pigs. A 3-phase, 98 d grow-finish feeding program was used. Day 98 for each block was considered the end of the feeding portion of the trial and all pigs were weighed in order to calculate growth characteristics. On day 98, the heaviest pig from each pen (40 pigs per block; 80 pigs total) was removed and transported to the University of Illinois Meat Science Laboratory (Urbana, IL) for slaughter on day 99. Also on day 99, the second heaviest and lightest pigs from each pen (80 pigs per block; 160 pigs total) were removed and transported to a federally inspected abattoir. These pigs were not used in the calculation of correlation coefficients. The remaining pig (third heaviest) was slaughtered at the University of Illinois Meat Science Laboratory on day 101 (40 pigs per block; 80 pigs total). In total, 160 of the 320 pigs were slaughtered at the University of Illinois Meat Science Laboratory and used to calculate correlation coefficients. Pigs were transported to the University of Illinois Meat Science Laboratory (Urbana, IL) and were held in lairage for approximately 16 h prior to slaughter. They were provided ad libitum access to water but had no access to feed during this time. Pigs were weighed immediately before slaughter to determine an ending live weight and were slaughtered under the supervision of the Food Safety and Inspection Service of the U.S. Department of Agriculture (USDA). Pigs were immobilized using head-to-heart electrical stunning and terminated via exsanguination. Carcasses were weighed approximately 45 min postmortem to determine hot carcass weight (HCW). Carcasses were chilled at 4 °C for a minimum of 20 h. Early and aged loin quality evaluations were collected on 80 barrow carcasses and 80 gilt carcasses slaughtered on 4 different days.

Abattoir Data Collection

Estimates of carcass composition were determined on the left side of each carcass, which was separated between the 10th and 11th rib to expose the longissimus dorsi. Tenth-rib back fat thickness was measured at three-fourth the distance of the longissimus dorsi from the dorsal process of the vertebral column. Loin muscle area was measured by tracing the cut surface of the longissimus dorsi on acetate paper. The longissimus dorsi tracings were measured in duplicate and the average of the 2 measurements was reported as loin muscle area. Standardized fat-free lean percentage was calculated using the equation ([8.588 + {0.465 × HCW, lb} − {21.896 × fat thickness, in} + {3.005 × loin muscle area, in^2}]/HCW, lb) × 100 as described in procedure 1 for ribbed carcasses (Burson and Berg, 2001).

Early Postmortem Pork Quality Evaluation

The left side of each carcass was fabricated according to the North American Meat Processors and loin primal pieces were further fabricated into boneless Canadian back loins (NAMP #414). Day 1 loin weight (anterior and posterior portion) was recorded immediately following fabrication prior to early postmortem quality evaluation. Early postmortem quality measurements for instrumental color, visual color, visual marbling, subjective firmness, and ultimate pH were conducted by trained University of Illinois personnel. The cut surface of the longissimus dorsi, posterior to the 10th rib, of each loin was re-surfaced and evaluated for quality parameters. Oxygenation of myoglobin on both the ventral and cut surface occurred at 4 °C for approximately 20 min before quality measurements were evaluated. Brewer et al. (2001) reported that time of oxygen exposure from 0 to 30 min had no effect on instrumental lightness (L*) and instrumental redness (a*) values did not change after 10 min of oxygen exposure. Therefore, 20 min was determined sufficient for oxygenation of myoglobin to occur. Instrumental L*, a*, and b* values (CIE, 1978) were measured with a Minolta CR-400 Chroma meter (Minolta Camera Co., Ltd., Osaka, Japan) using a D65 light source, 2° observer angle, and 8 mm aperture calibrated using a white tile. Ultimate pH was measured on the ventral side of the longissimus dorsi muscle in the approximate location of the 10th rib using a Reed data logger, calibrated at 4 °C, fitted with a Hanna glass electrode (REED SD-230 Series pH/ORP Datalogger, 0.00 to 14.00 pH/0 to 199 mV; Hanna FC200B electrode). Visual color and marbling scores (NPPC, 1999) and subjective firmness scores (NPPC, 1991) were determined by a single technician. After 1 d postmortem quality measures were complete, loins were vacuum packaged and aged for 13 d at 4°C.

Aged Postmortem Loin Quality Evaluation

Loin and chop quality. At 14 d postmortem, loins were removed from the packaging, allowed to drip for approximately 20 min, and weighed. Purge loss (%) was calculated using the following equation:

$$\text{Purge loss, \%} = \left(\begin{matrix}[1\text{ d weight, kg} - 14\text{ d weight, kg}]\\ /1\text{ d weight, kg}\end{matrix}\right) \times 100$$

Loins were exposed to oxygen (fat side against the table and epimysium removed with the lean side up) for at least 20 min. Then quality measurements for instrumental color, visual color, visual marbling, subjective firmness, and aged ultimate pH were conducted on the ventral surface of the exposed lean using the same procedures as the 1 d postmortem quality evaluations using the manner described by Lowell et al. (2017). Ambient room temperature during evaluations was approximately 4 °C. After quality evaluations were completed on the ventral surface of the loins, 3 loin chops from each loin were removed, posterior to the cut at the 10th rib, for evaluation of proximate composition (moisture and extractable lipid), cook loss, and Warner-Bratzler shear force (**WBSF**). Chops were sliced into 2.54-cm-thick chops using a Bizerba deli slicer SE 12 D US (Bizerba USA Inc., Piscataway, NJ). Chop 1 was exposed to oxygen for at least 20 min before evaluation. Then, instrumental L*, a*, and b* values (CIE, 1978) were measured with a Minolta CR-400 Chroma meter (Minolta Camera Co., Ltd.) using a D65 light source, 2° observer angle, and 8 mm aperture calibrated using a white tile. Visual color and marbling scores (NPPC, 1999), and subjective firmness scores (NPPC, 1991) were determined by a single technician. Chop 1 was then trimmed free of all subcutaneous fat and secondary muscles, packaged in Whirl-Pak bags (Nasco, Fort Atkinson, WI), and stored at −20 °C until determination of moisture and extractable lipid. Chop 2 was vacuum packaged and stored at −20 °C until determination cook loss (%) and WBSF. Chop 3 was vacuum packaged and stored at −20 °C as an archived sample.

Cook Loss and WBSF

The 2.54-cm-thick chops were removed from the freezer at least 24 h prior to analysis and allowed to thaw thoroughly at approximately 1 °C.

Chops were individually weighed and then cooked on a Farberware Open Hearth grill (model 455N, Walter Kidde, Bronx, NY). Chops were cooked, on one side, to an internal temperature of 31.5 °C, flipped, and then cooked until they reached an internal temperature of 63 °C, at which point they were removed. Internal temperature, during cooking, was monitored using copper-constantan thermocouples (Type T, Omega Engineering, Stamford, CT) placed in the approximate geometric center of each chop and connected to a digital scanning thermometer (model 92000-00, Barnat Co., Barrington, IL). Chops were allowed to cool to approximately 25 °C and weighed again to determine percent cook loss. Five 1.25-cm-diameter cores were removed parallel to the orientation of the muscle fibers and sheared using a Texture Analyzer TA.HD Plus (Texture Technologies Corp., Scarsdale, NY/Stable Microsystems, Godalming, UK) with a blade speed of 3.33 mm/s and a load cell capacity of 100 kg. The shear force values for the 5 cores were averaged and the average was reported as WBSF.

Proximate Composition

Chops stored for analysis of moisture and extractable lipid were allowed to partially thaw, with great care taken to prevent loss of exudate. Samples were homogenized using a Cuisinart food processor (East Windsor, NJ). After homogenization, two 10-g samples from the homogenate were weighed and placed in a drying oven at 110 °C for at least 24 h. Samples were then weighed to determine moisture and washed multiple times in a mixture of chloroform and methanol for at least 8 h in the manner described by Novakofski et al. (1989). After extraction, samples were dried for at least 24 h before the lipid extracted weight was recorded.

Statistical Analysis

Early and late quality evaluations were compared within a loin from the same pig therefore, pig served as the experimental unit for all statistical analyses. Carcass and loin quality characteristics from both sire lines were compared using a 1-way ANOVA in the MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). The model included the fixed effect of sire line and the random effect of block. Differences in quality traits between Pietrain-sired pigs and Duroc-sired pigs were considered different at $P \leq 0.05$.

Comparisons of independent correlation coefficients between Pietrain-sired pigs and Duroc-sired pigs were achieved following the example of Kenny (1987) and Lowell et al. (2017) using a z-test for comparing 2 independent correlations. First, data were grouped into 2 individual data sets by sire line (Pietrain-sired pigs and Duroc-sired pigs). For each of these 2 data sets, Pearson correlations coefficients were calculated and transformed using the Fisher's r to z transformation with the FISHER option of the CORR procedure in SAS. The Fisher's r to z transformation was defined as:

$$z = \frac{1}{2}\ln\left[\frac{1+r}{1-r}\right],$$

and used to ensure the transformed coefficients were nearly normally distributed and to make the variance of correlations approximately the same regardless of the value of the population correlation (Kenny, 1987). Where r is the Pearson correlation coefficient and z is the transformed value of the correlation coefficient.

If the z value was statistically significant, then the correlations between the 2 populations (Pietrain-sired pigs and Duroc-sired pigs) differ (Kenny, 1987). Next, Fisher's transformed z values were merged into a single data set and compared using the equation:

$$z = \frac{z_{\text{Pietrain}} - z_{\text{Duroc}}}{\sqrt{\dfrac{1}{n_{\text{Pietrain}} - 3} + \dfrac{1}{n_{\text{Duroc}} - 3}}}$$

Taylor (1990) cautions that correlation coefficients of 0.20 in data sets with more than 100 observations, like this data set, can be statistically different from 0 ($\alpha = 0.05$), but have little practical importance. Correlations were considered weak (in absolute value) at $r \leq 0.35$, correlations were considered moderate at $0.36 \leq r \leq 0.67$, and strong correlations were those $r \geq 0.68$ (Taylor, 1990). Therefore, differences in correlations of early and aged postmortem loin quality between Pietrain-sired pigs and Duroc-sired pigs were considered significant at $P \leq 0.05$ but must have had a correlation coefficient of $|r| \geq 0.36$ to be discussed as practically relevant.

RESULTS

Differences Between High Lean and High-Quality Sire Lines for Early and Late Postmortem Quality Characteristics

Ending live weight and HCW did not differ ($P \geq 0.66$, Table 1) between Duroc-sired and Pietrain-sired pigs. Duroc-sired pigs had a greater percent carcass yield ($P < 0.01$) and were fatter ($P < 0.001$) than the Pietrain-sired pigs. The Pietrain-sired pigs had a greater ($P < 0.01$) percent standardized fat-free lean; however, the 2 groups did not differ ($P \geq 0.85$) in loin eye area, loin weight, or loin weight as a percent of HCW (Table 1). Early postmortem ventral L* and a* were greater ($P < 0.01$) in loins from the Pietrain-sired pigs, whereas early postmortem ventral visual marbling and ultimate pH were greater ($P < 0.01$) in loins from the Duroc-sired pigs. There were no other differences ($P \geq 0.07$) in early postmortem loin quality between the 2 groups.

Loins from the Duroc-sired pigs had greater aged postmortem ventral visual marbling ($P = 0.03$) and ultimate pH ($P < 0.001$) compared with loins from the Pietrain-sired pigs (Table 2). Aged postmortem ventral L*, a*, b*, visual color, subjective firmness, and percent purge did not differ ($P \geq 0.09$) between the Pietrain-sired pigs and Duroc-sired pigs.

Aged chop face visual marbling ($P < 0.001$) and percent extractable lipid ($P = 0.02$) were greater in loins from Duroc-sired pigs, whereas loins from Pietrain-sired pigs had a greater ($P = 0.02$) percent moisture. WBSF values were greater ($P = 0.02$) for aged chops from Duroc-sired pigs compared with aged chops from Pietrain-sired pigs. There were no

Table 1. Carcass characteristics and early postmortem meat quality traits of Pietrain- and Duroc-sired pigs collected on the ventral side of the longissimus muscle

	Sire			
Item	Pietrain	Duroc	SEM	*P* value
Pigs, *n*	80	80		
Carcass characteristics				
Ending live wt, kg	130.87	130.69	3.28	0.88
Hot carcass wt, kg	103.20	103.66	2.58	0.66
Carcass yield, %	78.82	79.31	0.12	<0.01
10th rib fat thickness, cm	1.60	1.93	0.14	<0.001
Loin muscle area, cm^2	55.58	55.40	0.98	0.85
Standardized fat-free lean, %[1]	55.76	54.36	0.71	<0.001
Canadian back loin (NAMP #414) wt, kg	3.86	3.87	0.09	0.93
% chilled carcass wt	7.52	7.50	0.07	0.89
Early postmortem ventral quality traits[2]				
Instrumental color[3]				
Lightness, L*	48.33	48.09	0.86	0.60
Redness, a*	10.10	10.01	0.61	0.69
Yellowness, b*	3.52	3.13	0.46	0.07
Subjective evaluations[4]				
Visual color score	3.43	3.44	0.06	0.88
Visual marbling score	1.76	2.15	0.14	<0.01
Firmness score	3.64	3.56	0.05	0.21
Ventral loin pH[5]	5.53	5.57	0.02	<0.001

[1]Standardized fat-free lean = ([8.588 + {0.465 × HCW, lb} − {21.896 × fat depth, in} + {3.005 × longissimus thoracis area, in^2}]/HCW) × 100 (Burson and Berg, 2001).

[2]Ventral quality was evaluated on the exposed lean tissue (epimysium removed) of loins exposed to oxygen for at least 20 min.

[3]L* measures darkness to lightness (greater L* indicates a lighter color), a* measures redness (greater a* indicates a redder color), and b* measures yellowness (greater b* indicates a more yellow color).

[4]Evaluations based on NPPC (1991, 1999) standards, where 1 = visually palest color and 6 = visually darkest color; 1 = visually the least marbling and 6 = visually the most marbling; and 1 = softest and 6 = firmest.

[5]Loin pH was measured on the ventral surface of the boneless loins at the area of the 10th rib.

Table 2. Aged postmortem (14 d) meat quality traits of Duroc- and Pietrain-sired pigs collected on the ventral side or chop face of the longissimus muscle

	Sire			
Item	Pietrain	Duroc	SEM	*P* value
Pigs, *n*	80	80		
Ventral				
Instrumental color[1]				
Lightness, L*	50.19	49.61	0.35	0.19
Redness, a*	10.49	10.61	0.28	0.58
Yellowness, b*	5.09	4.80	0.33	0.15
Subjective evaluations[2]				
Visual color score	3.29	3.42	0.09	0.09
Visual marbling score	2.16	2.39	0.17	0.03
Subjective firmness score	3.70	3.71	0.04	0.82
Ultimate pH	5.58	5.63	0.03	<0.001
Aged loin wt, kg	3.58	3.60	0.09	0.72
Purge loss[3], %	7.31	6.97	0.19	0.20
Chop				
Instrumental color[1]				
Lightness, L*	52.22	51.79	0.58	0.42
Redness, a*	9.90	10.04	0.27	0.46
Yellowness, b*	4.50	4.43	0.36	0.75
Subjective evaluations				
Visual color score	3.21	3.32	0.05	0.07
Visual marbling score	2.04	2.68	0.10	<0.001
Subjective firmness score	3.08	3.15	0.07	0.19
Moisture, %	73.04	72.65	0.16	0.02
Extractable lipid, %	3.14	3.56	0.14	0.02
Warner-Bratzler shear force[4], kg	2.25	2.40	0.09	0.02
Cook loss[5], %	20.08	20.73	1.04	0.06

[1]L* measures darkness to lightness (greater L* indicates a lighter color), a* measures redness (greater a* indicates a redder color), and b* measures yellowness (greater b* indicates a more yellow color).

[2]Evaluations based on NPPC (1991, 1999) standards, where 1 = visually palest color and 6 = visually darkest color; 1 = visually the least marbling and 6 = visually the most marbling; and 1 = softest and 6 = firmest.

[3]Purge loss = ([1 d weight, kg − 14 d weight, kg]/1 d weight, kg) × 100.

[4]Chops used for Warner-Bratzler shear force were cooked to an internal temperature of 63 °C.

[5]Cook loss = ([initial weight, kg − cooked weight, kg]/initial weight, kg) × 100. Chops were cooked to an internal temperature of 63 °C.

differences ($P \geq 0.06$) in aged chop L*, a*, b*, visual color, subjective firmness, or percent cook loss between the Pietrain-sired pigs and Duroc-sired pigs.

Early Postmortem Ultimate pH

Early ultimate pH was moderately correlated with aged pH (Pietrain r = 0.56; Duroc r = 0.52) and aged ventral b* (Pietrain r = −0.45; Duroc r = −0.37) within both groups of pigs (Table 3). Early ultimate pH was moderately correlated (r = −0.45) with aged ventral L* within the Duroc-sired pigs but only weakly correlated (r = −0.34) within the Pietrain-sired pigs. Early ultimate pH was moderately correlated (r = 0.43) with aged ventral visual color within the Duroc-sired pigs but only weakly correlated (r = 0.22) within the Pietrain-sired pigs. Early ultimate pH was moderately correlated (r = −0.44) with chop L* within the Duroc-sired pigs but only weakly correlated (r = −0.33) within the Pietrain-sired pigs. Early ultimate pH was moderately correlated (r = 0.43) with chop visual color within the Duroc-sired pigs but only weakly correlated (r = 0.34) within the Pietrain-sired pigs. However, these correlations did not differ ($P \geq 0.10$) between the Pietrain-sired pigs and Duroc-sired pigs. Early ultimate pH was not correlated with early ventral a*, early ventral visual marbling, early ventral subjective firmness, chop a*, chop b*, chop visual marbling, or chop subjective firmness in either the Pietrain-sired pigs or Duroc-sired pigs.

Early Postmortem Ventral Instrumental Lightness (L)*

Early ventral L* was moderately correlated to aged ventral pH (Pietrain r = −0.40; Duroc r = −0.52), aged ventral L* (Pietrain r = 0.47; Duroc r = 0.65), and aged ventral visual color (Pietrain r = −0.42; Duroc r = −0.58) within both groups of pigs (Table 4). Early ventral L* was moderately correlated (r = −0.52) with chop color within the Duroc-sired pigs but only weakly correlated (r = −0.28) within the Pietrain-sired pigs. However, these correlations did not differ ($P \geq 0.08$) between the Pietrain-sired pigs and Duroc-sired pigs. Early L* was moderately correlated (r = 0.62) with aged ventral b* within the Duroc-sired pigs but only weakly correlated (r = 0.29) within the Pietrain-sired pigs and those correlations differed at P = 0.01. Early L* was moderately correlated (r = 0.64) with aged chop lightness within the Duroc-sired pigs but only weakly correlated (r = 0.35) within the Pietrain-sired pigs and those correlations differed at P = 0.02. Early L* was moderately correlated (r = 0.48) with aged chop b* within the Duroc-sired pigs but only weakly correlated (r = 0.28) within the Pietrain-sired pigs and those correlations difference at P = 0.02. Early L*

Table 3. Comparison of Fisher's r to z-transformed correlation coefficients (rho) of early postmortem loin pH values with aged loin quality and chop quality of Pietrain- and Duroc-sired pigs[1,2]

	Pietrain pH			Duroc pH			
		95% confidence limit			95% confidence limit		
Aged postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	P value[3]
Loin							
Loin pH	0.56	0.38	0.69	0.52	0.33	0.66	0.74
Ventral lightness, L*	−0.34	−0.52	−0.13	−0.45	−0.61	−0.25	0.44
Ventral redness, a*	−0.16	−0.37	0.06	0.11	−0.12	0.32	0.10
Ventral yellowness, b*	−0.45	−0.61	−0.25	−0.37	−0.54	−0.16	0.54
Ventral visual color	0.22	−0.01	0.42	0.43	0.23	0.59	0.14
Ventral visual marbling	0.25	0.03	0.45	0.27	0.05	0.47	0.89
Ventral subjective firmness	0.05	−0.17	0.27	0.01	−0.21	0.24	0.82
Chop							
Lightness, L*	−0.33	−0.51	−0.12	−0.44	−0.61	−0.24	0.40
Redness, a*	−0.20	−0.40	0.03	−0.17	−0.38	0.06	0.87
Yellowness, b*	−0.35	−0.53	−0.14	−0.34	−0.52	−0.12	0.92
Visual color	0.34	0.13	0.52	0.43	0.24	0.60	0.50
Visual marbling	0.05	−0.17	0.27	0.24	0.02	0.44	0.22
Subjective firmness	−0.08	−0.29	0.14	−0.02	−0.24	0.21	0.69

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Aged postmortem traits were evaluated 14 d postmortem.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

Table 4. Comparison of Fisher's *r* to *z*-transformed correlation coefficients (rho) of early postmortem instrumental lightness (L*) values with aged loin quality and chop quality of Pietrain- and Duroc-sired pigs[1,2]

	Pietrain L*			Duroc L*			
		95% confidence limit			95% confidence limit		
Aged postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	*P* value[3]
Loin							
Loin pH	−0.40	−0.57	−0.19	−0.52	−0.67	−0.34	0.32
Ventral lightness, L*	0.47	0.28	0.63	0.65	0.50	0.76	0.10
Ventral redness, a*	0.00	−0.22	0.22	0.17	−0.05	0.38	0.29
Ventral yellowness, b*	0.29	0.08	0.48	0.62	0.46	0.74	0.01
Ventral visual color	−0.42	−0.58	−0.22	−0.58	−0.71	−0.41	0.18
Ventral visual marbling	0.14	−0.08	0.35	−0.25	−0.44	−0.03	0.02
Ventral subjective firmness	−0.06	−0.27	0.17	0.14	−0.09	0.34	0.24
Chop							
Lightness, L*	0.35	0.14	0.53	0.64	0.49	0.76	0.02
Redness, a*	0.02	−0.20	0.24	0.22	0.00	0.42	0.22
Yellowness, b*	0.15	−0.07	0.36	0.48	0.29	0.64	0.02
Visual color	−0.28	−0.47	−0.07	−0.52	−0.66	−0.34	0.08
Visual marbling	0.09	−0.13	0.30	−0.07	−0.28	0.15	0.33
Subjective firmness	0.05	−0.17	0.27	0.10	−0.13	0.31	0.79

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Aged postmortem traits were evaluated 14 d postmortem.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

was not correlated with aged ventral a*, aged ventral visual marbling, aged subjective firmness, aged chop a*, aged chop visual marbling, or aged chop subjective firmness in either the Pietrain-sired pigs or Duroc-sired pigs.

Early Postmortem Ventral Instrumental Redness (a) and Yellowness (b*)*

Early ventral a* was moderately correlated with aged chop a* (Pietrain $r = 0.51$; Duroc $r = 0.51$) and aged chop b* (Pietrain $r = 0.41$; Duroc $r = 0.39$) within both groups of pigs (Table 5). Early ventral a* was moderately correlated ($r = 0.44$) with aged ventral a* within the Pietrain-sired pigs but only weakly correlated ($r = 0.33$) within the Duroc-sired pigs. Early ventral a* was moderately correlated ($r = 0.43$) with aged ventral b* within the Pietrain-sired pigs but only weakly correlated ($r = 0.24$) within the Duroc-sired pigs. These correlations did not differ ($P \geq 0.17$) between the Pietrain-sired pigs and the Duroc-sired pigs. Early ventral a* was not correlated with aged loin pH, aged ventral L*, aged ventral visual color, aged ventral visual marbling, aged subjective firmness, aged chop L*, aged chop visual color, aged chop visual marbling, or aged chop subjective firmness in either of the 2 groups of pigs.

Early ventral b* was moderately correlated with aged ventral b* (Pietrain $r = 0.47$; Duroc $r = 0.41$) and aged chop b* (Pietrain $r = 0.45$; Duroc $r = 0.45$) within both groups of pigs (Table 6). Early ventral b* was moderately correlated ($r = 0.45$) with aged chop L* within the Duroc-sired pigs but only weakly correlated ($r = 0.32$) within the Pietrain-sired pigs. Early ventral b* was moderately correlated ($r = -0.35$) with chop visual color within the Duroc-sired pigs but only weakly correlated ($r = -0.12$) within the Pietrain-sired pigs. These correlations did not differ ($P \geq 0.13$) between the Pietrain-sired pigs and the Duroc-sired pigs. Early ventral b* was not correlated with aged loin pH, aged ventral a*, aged ventral visual color, aged ventral visual marbling, aged ventral subjective firmness, aged chop a*, aged chop visual marbling, or aged chop subjective marbling in either the Pietrain-sired pigs or Duroc-sired pigs.

Early Postmortem Ventral Visual Color

Early ventral visual color was strongly correlated ($r = 0.73$) with aged ventral visual color within the Duroc-sired pigs and moderately correlated ($r = 0.63$) within the Pietrain-sired pigs (Table 7). Early ventral visual color was also moderately correlated with aged chop L* (Pietrain

Table 5. Comparison of Fisher's *r* to *z*-transformed correlation coefficients (rho) of early postmortem instrumental redness (a*) values with aged loin quality and chop quality of Pietrain- and Duroc-sired pigs[1,2]

	Pietrain a*			Duroc a*			
		95% confidence limit			95% confidence limit		
Aged postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	*P* value[3]
Loin							
Loin pH	0.00	−0.22	0.22	0.11	−0.11	0.33	0.49
Ventral lightness, L*	−0.04	−0.26	0.18	0.01	−0.22	0.23	0.77
Ventral redness, a*	0.44	0.25	0.61	0.33	0.12	0.51	0.41
Ventral yellowness, b*	0.43	0.23	0.59	0.24	0.02	0.43	0.17
Ventral visual color	0.09	−0.13	0.31	0.03	−0.19	0.25	0.71
Ventral visual marbling	−0.04	−0.26	0.18	0.22	0.00	0.42	0.10
Ventral subjective firmness	−0.04	−0.26	0.18	0.20	−0.03	0.40	0.14
Chop							
Lightness, L*	0.11	−0.12	0.32	0.23	0.01	0.43	0.43
Redness, a*	0.51	0.33	0.66	0.51	0.32	0.65	0.97
Yellowness, b*	0.41	0.21	0.58	0.39	0.18	0.56	0.89
Visual color	0.11	−0.11	0.32	−0.05	−0.27	0.17	0.33
Visual marbling	0.03	−0.19	0.25	0.32	0.10	0.50	0.06
Subjective firmness	−0.17	−0.38	0.05	−0.10	−0.32	0.12	0.68

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Aged postmortem traits were evaluated 14 d postmortem.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

Table 6. Comparison of Fisher's *r* to *z*-transformed correlation coefficients (rho) of early postmortem instrumental yellowness (b*) values with aged loin quality and chop quality of Pietrain- and Duroc-sired pigs[1,2]

	Pietrain b*			Duroc b*			
		95% confidence limit			95% confidence limit		
Aged postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	*P* value[3]
Loin							
Loin pH	−0.01	−0.23	0.21	−0.12	−0.33	0.10	0.50
Ventral lightness, L*	0.22	0.00	0.42	0.35	0.14	0.53	0.37
Ventral redness, a*	0.23	0.01	0.42	0.20	−0.02	0.40	0.87
Ventral yellowness, b*	0.47	0.28	0.62	0.41	0.21	0.58	0.64
Ventral visual color	−0.16	−0.37	0.06	−0.25	−0.45	−0.04	0.55
Ventral visual marbling	0.15	−0.08	0.36	0.11	−0.12	0.32	0.80
Ventral subjective firmness	−0.05	−0.27	0.17	0.20	−0.02	0.40	0.12
Chop							
Lightness, L*	0.32	0.11	0.51	0.45	0.26	0.61	0.34
Redness, a*	0.34	0.13	0.52	0.34	0.13	0.52	1.00
Yellowness, b*	0.45	0.25	0.61	0.45	0.26	0.61	0.96
Visual color	−0.12	−0.33	0.10	−0.35	−0.53	−0.14	0.13
Visual marbling	0.11	−0.11	0.33	0.25	0.03	0.44	0.40
Subjective firmness	−0.27	−0.46	−0.05	−0.05	−0.26	0.18	0.15

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Aged postmortem traits were evaluated 14 d postmortem.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

$r = -0.46$; Duroc $r = -0.60$) and aged chop visual color (Pietrain $r = 0.45$; Duroc $r = 0.57$) within both groups of pigs. Early ventral visual color was moderately correlated ($r = -0.39$) with chop b* within the Duroc-sired pigs but only weakly correlated ($r = -0.22$) within the Pietrain-sired pigs. However, none of these correlations differed ($P \geq 0.24$) between the Pietrain-sired pigs and the Duroc-sired

Table 7. Comparison of Fisher's *r* to *z*-transformed correlation coefficients (rho) of early postmortem visual color values with aged loin quality and chop quality of Pietrain- and Duroc-sired pigs[1,2]

	Pietrain color			Duroc color			
		95% confidence limit			95% confidence limit		
Aged postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	*P* value[3]
Loin							
Loin pH	0.09	−0.13	0.31	0.44	0.24	0.60	0.02
Ventral lightness, L*	−0.29	−0.48	−0.07	−0.57	−0.70	−0.40	0.03
Ventral redness, a*	0.27	0.05	0.46	0.10	−0.13	0.31	0.27
Ventral yellowness, b*	−0.03	−0.24	0.20	−0.45	−0.61	−0.25	0.01
Ventral visual color	0.63	0.48	0.75	0.73	0.61	0.82	0.25
Ventral visual marbling	−0.14	−0.35	0.09	0.32	0.10	0.50	< 0.01
Ventral subjective firmness	0.16	−0.07	0.36	0.10	−0.13	0.31	0.69
Chop							
Lightness, L*	−0.46	−0.62	−0.27	−0.60	−0.72	−0.43	0.24
Redness, a*	0.11	−0.11	0.33	−0.06	−0.27	0.17	0.30
Yellowness, b*	−0.22	−0.42	0.00	−0.39	−0.56	−0.19	0.24
Visual color	0.45	0.25	0.61	0.57	0.40	0.70	0.32
Visual marbling	0.00	−0.22	0.22	0.22	−0.01	0.42	0.17
Subjective firmness	−0.11	−0.32	0.12	−0.02	−0.24	0.20	0.58

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Aged postmortem traits were evaluated 14 d postmortem.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

pigs. Early ventral visual color was moderately correlated (r = 0.44) with aged pH within the Duroc-sired pigs but only weakly correlated (r = 0.09) within the Pietrain-sired pigs and those correlations differed at P = 0.02. Early ventral visual color was moderately correlated (r = −0.57) with aged ventral L* within the Duroc-sired pigs but only weakly correlated (r = −0.29) within the Pietrain-sired pigs and those correlations differed at P = 0.03. Early ventral visual color was moderately correlated (r = −0.45) with aged ventral b* within the Duroc-sired pigs but only weakly correlated (r = −0.03) within the Pietrain-sired pigs and those correlations differed at P = 0.01. Early ventral visual color was not correlated to aged ventral visual marbling, aged ventral subjective firmness, aged chop a*, aged chop visual marbling, and aged chop subjective firmness in either the Pietrain-sired pigs or Duroc-sired pigs.

Early Postmortem Ventral Visual Marbling

Early ventral visual marbling was moderately correlated with aged ventral visual marbling (Pietrain r = 0.56; Duroc r = 0.49) and strongly correlated with aged chop visual marbling (Pietrain r = 0.68; Duroc r = 0.84) within both groups of pigs (Table 8). Early ventral visual marbling was not correlated with any other aged loin and chop quality characteristics in either the Pietrain-sired pigs or Duroc-sired pigs.

Early Postmortem Quality Traits and WBSF and Cook Loss

No early postmortem quality traits were correlated with WBSF or cook loss for either the Pietrain-sired pigs or Duroc-sired pigs (Table 9).

DISCUSSION

Mexico imports the most U.S. pork on a total volume basis, but Japan is the greatest importer of U.S. pork on a total value basis (National Pork Board, 2017). Japanese importers prefer a darker, more highly marbled product, and Mexican importers prefer a high lean product (Murphy et al., 2015; Ngapo et al., 2018). The contrasting demands of these 2 export markets and similar demands within the U.S. market have resulted in the need for both lean growth and meat quality production focuses. As producers are faced with the challenge of meeting specific requirements of distinct markets (lean growth vs. meat quality), pork quality and carcass characteristics are now considered essential breeding objectives and integrated into many breeding programs (Miar et al., 2014). Based on genetic differences between breeds and genetic variation within breeds for meat quality traits, genetic changes in meat quality are possible through breed substitution and selection technologies (Cameron et al., 1999).

Table 8. Comparison of Fisher's *r* to *z*-transformed correlation coefficients (rho) of early postmortem visual marbling values with aged loin quality and chop quality of Pietrain- and Duroc-sired pigs[1,2]

	Pietrain marbling			Duroc marbling			
		95% confidence limit			95% confidence limit		
Aged postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	*P* value[3]
Loin							
Loin pH	0.23	0.01	0.43	0.29	0.07	0.48	0.26
Ventral lightness, L*	0.11	−0.12	0.32	−0.11	−0.32	0.11	0.09
Ventral redness, a*	−0.06	−0.27	0.17	0.11	−0.11	0.32	0.42
Ventral yellowness, b*	0.10	−0.13	0.31	−0.04	−0.25	0.19	0.27
Ventral visual color	0.03	−0.19	0.25	0.12	−0.10	0.33	0.39
Ventral visual marbling	0.56	0.39	0.70	0.49	0.30	0.64	0.61
Ventral subjective firmness	0.10	−0.12	0.31	0.33	0.12	0.51	0.62
Chop							
Lightness, L*	0.01	−0.21	0.23	0.02	−0.21	0.24	0.91
Redness, a*	0.10	−0.13	0.31	0.23	0.01	0.43	0.95
Yellowness, b*	0.17	−0.05	0.38	0.18	−0.05	0.38	0.95
Visual color	0.12	−0.10	0.33	0.14	−0.08	0.35	0.86
Visual marbling	0.68	0.55	0.79	0.84	0.77	0.90	0.93
Subjective firmness	0.11	−0.12	0.32	0.02	−0.20	0.24	0.30

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Aged postmortem traits were evaluated 14 d postmortem.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

Table 9. Comparison of Fisher's *r* to *z*-transformed correlation coefficients (rho) of early postmortem loin quality traits between Pietrain- and Duroc-sired pigs with Warner-Bratzler shear force (WBSF) and cook loss[1,2]

	Pietrain			Duroc			
		95% confidence limit			95% confidence limit		
Early postmortem variable	Rho	Lower	Upper	Rho	Lower	Upper	*P* value[3]
WBSF							
Loin pH	0.00	−0.22	0.22	0.04	−0.19	0.26	0.84
Ventral lightness, L*	0.06	−0.16	0.28	−0.09	−0.31	0.13	0.35
Ventral redness, a*	−0.06	−0.27	0.17	0.07	−0.16	0.28	0.45
Ventral yellowness, b*	−0.16	−0.37	0.06	−0.05	−0.27	0.17	0.49
Ventral visual color	0.14	−0.08	0.35	0.09	−0.13	0.30	0.76
Ventral visual marbling	−0.10	−0.31	0.12	−0.20	−0.40	0.02	0.54
Ventral subjective firmness	0.05	−0.17	0.27	−0.06	−0.27	0.16	0.51
Cook loss, %							
Loin pH	−0.34	−0.52	−0.13	−0.21	−0.41	0.02	0.37
Ventral lightness, L*	0.08	−0.14	0.30	0.19	−0.03	0.40	0.49
Ventral redness, a*	0.15	−0.07	0.36	0.03	−0.19	0.25	0.45
Ventral yellowness, b*	0.15	−0.07	0.36	0.05	−0.17	0.27	0.55
Ventral visual color	−0.13	−0.34	0.10	−0.11	−0.32	0.11	0.92
Ventral visual marbling	−0.19	−0.39	0.03	−0.30	−0.49	−0.09	0.47
Ventral subjective firmness	−0.17	−0.38	0.05	−0.02	−0.24	0.20	0.36

[1]Early postmortem traits were evaluated 1 d postmortem.

[2]Chops for Warner-Bratzler shear force and cook loss were aged for 14 d postmortem prior to analyses.

[3]Probablity value comparing correlation coefficients of meat quality traits between Pietrain- and Duroc-sired pigs.

Historical differences in carcass characteristics and carcass yield between Duroc and Pietrain-sired pigs are well documented (Affentrager et al., 1996; Ellis et al., 1996; Edwards et al., 2003) and results of this study reflect those of previous research. The Duroc breed is used extensively in production of crossbred market hogs because of its meat quality advantages (Schwab et al., 2006), and the Pietrain breed is commonly used to satisfy the demand for lean pork exported to Mexico (Edwards et al., 2003). In the present study, Duroc-sired pigs produced more highly marbled, meeting the demands of a quality export market. This is supported by previous research (Edwards et al., 2003) which also observed darker, more highly marbled loins from a meat quality sire line compared with a lean growth sire line. However, the meat quality traits between the 2 breeds did not differ to the magnitude expected based on historical data.

The ultimate goal of packer selection of high-quality loins is to increase consumer satisfaction and therefore increase consumer purchases of product. Historically, meat quality traits such as visual color, visual marbling, and percent drip loss differ between meat quality and lean growth sire lines (Edwards et al., 2003; Arkfeld et al., 2016). These differences can influence selection for premium-based programs by the packer, as well as consumer purchase intent (Edwards et al., 2003; Lonergan et al., 2007; Moeller et al., 2010). While packers estimate quality on the ventral surface of a boneless loin after carcass fabrication, consumers often observe the cut surface of loin chops. Packers determine loin quality based on color and marbling on the ventral surface of loins during carcass fabrication at 1 d postmortem (King et al., 2011). At this time, darker loins with more marbling are often selected for premium-based programs, many of which are exported to countries with a demand for high-quality products (Holmer and Sutton, 2009; Lusk et al., 2017). This selection is possible as early postmortem quality characteristics and eating quality are correlated (Huff-Lonergan et al., 2002). Huff-Lonergan et al. (2002) reported that loin pH at 24 h postmortem was weakly correlated to aged L* ($r = -0.32$), aged ventral firmness ($r = 0.20$), cook loss ($r = -0.20$), tenderness ($r = 0.27$), juiciness ($r = 0.17$), and flavor ($r = 0.25$). It has also been established that there are correlations between early postmortem loin quality characteristics and aged loin and chop quality characteristics, and these correlations largely do not differ between barrows and gilts (Lowell et al., 2017). Lowell et al. (2017) reported that early postmortem (1 d) loin pH was strongly correlated with aged pH ($r = 0.80$ barrows; 0.75 gilts). Early pH was moderately correlated with aged ventral L* ($r = -0.57$ barrows; −0.54 gilts), aged subjective ventral color ($r = 0.55$ barrows; 0.41 gilts), and aged subjective chop color ($r = 0.42$ barrows; 0.44 gilts) (Lowell et al., 2017). Early ventral L* was moderately correlated with aged ventral L* ($r = 0.60$ barrows; 0.51 gilts) (Lowell et al., 2017). Early ventral visual marbling was moderately correlated with aged ventral visual marbling ($r = 0.67$ barrows; 0.66 gilts) and visual aged chop marbling ($r = 0.57$ barrows; 0.59 gilts) (Lowell et al., 2017). However, with the use of both meat quality and lean growth sire lines, to meet demands of varying export markets, correlations between early loin quality characteristics and aged loin and chop quality characteristics must also be established. Due to the established differences in meat quality between breeds characterized as meat quality and breeds characterized as lean growth, it was expected that correlations between early loin quality characteristics and aged loin and chop quality characteristics would differ between Duroc- and Pietrain-sired pigs.

In the present study, loin pH at 1 d postmortem was correlated to aged ventral L* (Pietrain $r = -0.35$; Duroc $r = -0.45$), aged ventral visual color (Pietrain $r = 0.22$; Duroc $r = 0.43$), aged chop L* (Pietrain $r = -0.33$; Duroc $r = -0.44$), and aged chop visual color (Pietrain $r = 0.34$; Duroc $r = 0.43$). This is supported by previous research (Hamilton et al., 2003) which reported correlations of early loin pH with aged loin L* ($r = -0.77$). Another study, Huff-Lonergan et al. (2002), reported a correlation between pH and aged loin color ($r = 0.30$). However, both the study by Hamilton et al. (2003) and Huff-Lonergan et al. (2002) aged loins for approximately 48 h postmortem and, therefore, may not accurately represent the quality traits observed by the consumer, which usually occurs after a longer aging period. The difference in time of aging may also explain the differences between the correlations observed in previous studies by Hamilton et al. (2003) and Huff-Lonergan et al. (2002) compared to correlations observed in the present study.

Correlations between early color and aged color were supported by the moderate correlation between early ventral L* and aged ventral visual color (Pietrain $r = -0.42$; Duroc $r = -0.54$). Lowell et al. (2017) also reported a correlation between early L* and aged ventral visual color (Barrows $r = -0.39$; Gilts $r = -0.08$). Previous research (Huff-Lonergan et al., 2002; Boler et al., 2010) also reported moderate to strong correlations between L* and visual color. Correlations between early L* and aged chop L*, and early visual color and aged L* differed between the Duroc-sired pigs and the Pietrain-sired pigs. It is possible that these differences are due to differences in muscle fiber type. Based on previous research, it could be concluded that correlation differences in early and aged color characteristics could be due an increase in glycolytic fibers within the Pietrain-sired pigs (Klont et al., 1998). Intensive genetic selection for lean muscle growth, of the Pietrains, has likely caused a shift in fiber type composition, resulting in a greater proportion of glycolytic fibers and a reduced frequency of oxidative fibers (Klont et al., 1998). An increase in glycolytic fiber type tends to increase L* and decrease water-holding capacity (WHC), whereas an increase in oxidative fiber type tends to decrease L*, increase a*, and increase WHC, resulting in a more visually appealing cut of meat (Klont et al., 1998; Joo et al., 2013). Increased myoglobin is also associated with an increase in oxidative muscle fibers (Joo et al., 2013). Therefore, in Duroc-sired pigs where color would be expected to be darker and WHC greater, the correlation between early and aged measures of color were stronger. This difference in color could, therefore, be, in part, due to an increase in myoglobin associated with an increase in oxidative muscle fibers (Joo et al., 2013). There was also a correlation between early ventral a* and aged chop a* yet previous work by Lowell et al. (2017) reported that correlations did not exist between early ventral a* and aged chop a*. The aforementioned differences in fiber types between Pietrain and Duroc pigs may explain the correlation between early ventral a* and aged chop a* observed in this present study. An increased proportion of oxidative fiber types, seen in Duroc pigs, often results in a darker, more red loin (Joo et al., 2013). Differences in mean pH between sire lines could also be explained by the differences in muscle fiber type. A greater amount of glycolytic fibers decreases pH through rapid glycolysis and accumulation of lactate (Choi et al., 2007). Even so, the differences in pH were not great enough to influence correlations between early pH and aged pork quality traits. Another explanation for the correlation differences, observed in this study, between sire lines could be the increased variability in the Duroc-sired pigs. A study by Arkfeld et al. (2017) also reported that pigs destined for a quality-focused market were more variable compared with pigs destined for a lean-focused market.

The ultimate goal of selecting loins based on quality characteristics in the early postmortem period is to segregate loins into categories that provide an expected eating experience. Tenderness is often cited as the most important for consumer eating experience (Moeller et al., 2010). Based on this, correlations between early postmortem quality characteristics and tenderness are important. It should be noted that the loin chops from the Pietrain-sired pigs were actually more tender than chops from the Duroc-sired pigs. However, the magnitude of difference was not great enough to influence correlations between early postmortem quality and tenderness, and chops from both groups of pigs would be considered tender. Previous work has also reported no correlations between instrumental or visual color parameters and instrumental or sensory tenderness (Harsh et al., 2018).

Moderate correlations between early ventral visual marbling and aged ventral visual marbling as well as strong correlations between early ventral visual marbling and aged chop visual marbling, within both sire lines, indicate that early postmortem estimates of marbling, on the ventral surface, are correlated with aged estimates of marbling. However, early ventral visual marbling was not correlated with WBSF in meat quality or lean growth sire lines. Wilson et al. (2017) reported that extractable lipid (range 0.80% to 5.52%) explained less than 1% of the variation in sensory tenderness of pork loin chops cooked to a medium-rare degree of doneness (63 °C). Additionally, Rincker et al. (2008) reported that extractable lipid (range 0.76% to 8.09%) did not influence instrumental or sensory tenderness of pork loins cooked to a medium (71 °C) degree of doneness.

Unlike beef carcasses, pork carcasses are not usually ribbed (cut between the 10th and 11th rib to expose the longissimus muscle) in the United States. The amount of epimysium left on the ventral surface of a pork loin during fabrication can affect what portion (anterior or posterior) of the ventral surface is visible for color evaluation. Several studies have observed that color is not consistent between the anterior and posterior ends of the longissimus muscle (Van Oeckel and Warnants, 2003; Homm et al., 2006). Due to differences in color between the anterior and posterior ends of the longissimus muscle, it is important to be consistent when evaluating color quality on the ventral surface.

Based on the results of the present study, it may be possible to use early L* and ventral visual color as indicators of aged chop color. Additionally, early ventral visual marbling could be used to estimate marbling in both aged loins and aged loin chops. The majority of correlation comparisons did not differ between Duroc- and Pietrain-sired pigs; however, there were some early postmortem quality characteristics that were correlated in the Duroc-sired pigs but not the Pietrain-sired pigs, most likely due to the afore mentioned quality differences between the 2 breed types. While there were differences between Duroc- and Pietrain-sired pigs in terms of quality characteristics, the majority of correlations between early and aged quality did not differ between the 2 sire lines. Therefore, the same early postmortem quality traits can be used to predict aged quality regardless of sire line. Additionally, it is not necessary to account for sire line when using early postmortem quality traits to estimate aged quality observed by the consumer.

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