Meat and Muscle Biology™

Predicting Pork Loin Chop Quality Traits Using Ventral Surface Assessment

Yifei Wang, Rebecca A. Brown, Milena Conte, and Benjamin M. Bohrer*

Department of Animal Sciences, The Ohio State University, Columbus, OH 43210, USA
*Corresponding author. Email: bohrer.13@osu.edu (Benjamin M. Bohrer)

Abstract: The objective was to determine the prediction ability of pork loin chop quality when assessing the ventral surface of loins, while controlling postmortem aging time and environmental conditions of evaluation. A total of 154 pork loins were used for this evaluation, stemming from 3 populations. At day 14 postmortem, subjective color, marbling, and firmness, as well as instrumental color (using a Minolta CM-700d) were evaluated by 3 trained technicians on the ventral surface of the loins. Loins were immediately cut into 2.5-cm thick chops, allowed to bloom for 30 min, and the chop from the center of the loin (approximately 10th rib location) was assessed for quality by the same 3 trained technicians. In addition, pH, purge loss, intramuscular fat (IMF) content *via* FOSS Foodscan, cooking loss, and Warner-Bratzler shear force were measured using center-cut chops. Pearson correlation coefficients were calculated for all response variables. Multiple linear regression analysis was performed with forward stepwise selection criteria set to a significance level for entry of 0.15. Dependent variables evaluated were loin chop subjective color, loin chop instrumental color (L*, a*, and b*), loin chop subjective marbling, IMF, and loin chop subjective firmness. Independent variables were ventral surface quality parameters when loin chop quality parameters served as the dependent variables, and both ventral surface and loin chop quality parameters when IMF served as the dependent variable. Subjective color of pork loin chops could be moderately predicted using ventral surface subjective color and ventral surface Minolta a* (Model $R^2 = 0.53$), and subjective marbling of pork loin chops could be moderately predicted using IMF content via FOSS Foodscan, ventral surface subjective color, ventral surface marbling, and ventral surface Minolta a* (Model $R^2 = 0.65$). When using ventral surface quality traits for pork loins, only moderate prediction ability with center-cut loin chops should be expected.

Key words: pork quality, pork color, pork marbling, stepwise regression, quality prediction
Meat and Muscle Biology 10(1): 22110, 1–12 (2026) **doi:10.22175/mmb.22110**
Submitted 17 December 2025 Accepted 20 March 2026

Introduction

Markets around the world rely on accurate and efficient prediction of pork quality traits such as color, marbling, and firmness. A significant challenge for the prediction of pork loin quality is that loins are typically not cut into chops until they reach the end-use channel (i.e., retail or foodservice sector). Thus, quality on the exposed surface of loin chops must be predicted using either the exposed lean on the most anterior end of the loin, the exposed lean on the most posterior end of the loin, or the exposed lean on the ventral surface of boneless loins. Previous research suggested that anterior and posterior chops may have potential to classify center-cut chops by color in very pale and very dark loins (assessed using image analysis); however, color of the exposed lean on the ventral surface of boneless loins had superior correlation coefficients with center-cut chop color (assessed using image analysis) when compared with anterior and posterior chops (Wei et al., 2024). Furthermore, center-cut chops of pork loins have been shown to have lower levels of intramuscular fat (IMF) compared with the most anterior end and the most posterior end of loins (Mandell et al., 2006; Redifer et al., 2020; Uttaro et al., 2021), thus exploring the prediction ability of the center-cut chop marbling using ventral surface marbling is also of interest.

The most robust study to-date on this topic explored the association between early postmortem (1 d) ventral surface quality with aged (12 to 28 d postmortem) ventral surface quality and aged (12 to 28 d postmortem) center-cut chop quality (Harsh et al., 2018). A limitation of this study was the lack of comparison between ventral surface quality and center-cut chop quality at the same time in the same environmental conditions (i.e., removing the known impact that postmortem aging has on quality traits [Lowell et al., 2017; Schulte et al., 2019] and removing the known impacts of environment and lighting conditions [Uttaro et al., 2025]). Thus, the objective was to determine the prediction ability of pork loin chop quality when assessing the ventral surface of loins, while controlling postmortem aging time and environmental conditions of evaluation.

Materials and Methods

Approval from the Institutional Animal Care and Use Committee was not required because live animals were not used in this study.

Sample collection

A total of 154 boneless pork loins (muscle: *longissimus thoracis et lumborum*) were purchased from a commercial processor that uses electrical stunning and conventional chilling (20–24 h of exposure to ambient temperatures of approximately 2°C). Loins originated from 3 different slaughter groups over a period of 4 months (slaughter event 1 = 64 loins; slaughter event 2 = 50 loins; slaughter event 3 = 40 loins). All loins were individually vacuum-sealed and transported under refrigeration from the commercial processor to the Ohio State University Meat Science Teaching Laboratory (a distance of approximately 185 km). Upon arrival at the Ohio State University Meat Science Teaching Laboratory, the loins remained in their individually vacuum-sealed packages and were aged in cardboard boxes in a 2°C refrigerated room until 14 d postmortem. At 14 d postmortem, the vacuum-sealed packaging was removed, and the *spinalis dorsi* and other associated muscles were trimmed to isolate the LTL muscle.

Quality analysis

Quality analysis took place in the Ohio State University Meat Science Teaching Laboratory on a common table under high bay metal halide lights (175 W, 4,000 K, General Electric, Boston, MA, USA). Loins were allowed to bloom (i.e., exposed to oxygen) for 30 min before the evaluation of ventral surface quality. Subjective color, marbling, and firmness were evaluated on the ventral surface near the center of the loins (10^{th} rib location) separately by 3 trained individuals according to standards published by the National Pork Producers Council (NPPC, 1991; NPPC, 1999). Averages among the 3 individuals were reported. Instrumental CIE (L^*, a^*, b^*) color values were evaluated on the ventral surface near the center of the loins (10^{th} rib location) using a handheld spectrophotometer with D_{65} light source, an 11-mm aperture, and a 10° observer (Minolta CM-700d; Minolta Corp., Osaka, Japan). The average of 3 different locations was used to report instrumental color values.

Loins were then cut into 2.5-cm chops while maintaining anatomical orientation. The chop from the center of the loins (10^{th} rib location) was allowed to bloom (i.e., exposed to oxygen) for 30 min before evaluation of loin chop quality. Subjective color, marbling, and firmness, as well as instrumental color, were immediately evaluated on the surface of loin chops using the same 3 individuals and under the same lighting conditions as with ventral surface quality.

Objective measurements were collected on the loins, which included pH, purge loss, IMF, cooking loss, and Warner-Bratzler shear force. The pH was measured in triplicate at approximately the 10^{th} rib location using a portable MPI pH meter (Meat Probes Inc., Topeka, KS, USA). The pH meter was calibrated with pH 4.01 and pH 7.00 buffers before use. Purge loss was measured before and after the loins were removed from vacuum-sealed packages. Loins and packages were blotted dry using paper towels, and packages were allowed to dry. Purge loss was evaluated using the packaged-muscle cut weight, out-of-package muscle cut weight, and the weight of the dried package, using the following equation: Purge loss = [(packaged-muscle cut weight – dried package weight – out-of-package muscle cut weight)/(packaged-muscle cut weight – dried package weight)] × 100. Intramuscular fat content was evaluated with near-infrared spectroscopy using a FOSS Foodscan™ (FOSS, Hillerod, Denmark). Two 2.5-cm thick chops were used for cooking loss and Warner-Bratzler shear force. Chops were randomly assigned to internal endpoint cooking temperatures of either 63°C or 71°C and cooked using the sous-vide cooking technique in a water bath (precision general purpose water bath; Thermo Fisher Scientific, Waltham, MA, USA). The water bath was set and maintained at a temperature of 80°C. Samples allotted to an endpoint temperature of 63°C were cooked for 30 min, while those assigned to an endpoint temperature of 71°C were cooked for 40 min. Internal cooking temperature was continuously monitored during cooking by inserting a digital temperature logger with 2 thermocouples into the center of a nonstudy reference pork chop sample of comparable weight and size to the study samples. Upon reaching the targeted endpoint cooking temperature, pork chops were immediately arranged in a single layer on a plastic tray and transferred to a 2°C refrigerated room for a period of approximately 12 h. The cooked pork chops were weighed after removal from the vacuum packages, and cooking loss was calculated as the percentage of weight difference between the initial raw weight and the cooked weight. Six 1.27-cm diameter cores parallel to the muscle fiber orientation were obtained from each cooked pork chop using a handheld coring device. Cores were sheared perpendicular to the fiber direction using a Warner-Bratzler shear attachment on a TA-XTplusC texture analyzer (Texture Technologies Corp., Hamilton, MA, USA). Pretest and test speeds of the instrument were set to 2 mm/sec, while post-test speed was set to 10 mm/s. The force was measured for a set distance of 20 mm. The peak force required to shear through each core was recorded, and the value for the 6 cores from each pork chop was averaged and reported as Warner-Bratzler shear force (WBSF).

Statistical analysis

Each loin sample ($n = 154$) served as an experimental unit. Summary statistics (mean, standard deviation, maximum, and minimum) were analyzed using the MEANS procedure of SAS v9.4 (SAS Institute Inc., Cary, NC, USA). Normality and homogeneity of variance were tested using the UNIVARIATE procedure in SAS, with consideration given to the Shapiro-Wilks test for normality, along with evaluating the Student Panel graphs generated with the GLIMMIX procedure of SAS.

Pearson correlation coefficients between variables were determined using the CORR procedure of SAS. For discussion purposes, correlations were considered weak at $|r| < 0.35$, moderate at $0.36 \leq |r| < 0.67$, and strong at $|r| \geq 0.68$ (Taylor, 1990). Multiple regression analysis was performed with the REG procedure of SAS using forward stepwise selection criteria set to a significance level for entry of 0.15. Dependent variables evaluated were loin chop subjective color, loin chop instrumental color (L^*, a^*, and b^*), loin chop subjective marbling, IMF, and loin chop subjective firmness. Independent variables were ventral surface quality parameters when loin chop quality parameters served as the dependent variables, and both ventral surface and loin chop quality parameters when IMF served as the dependent variable.

Results

Summary statistics and correlation analysis

Summary statistics provided baseline information for quality traits (Table 1). Pearson correlation coefficients for subjective color, instrumental color (L^*, a^*, and b^*), subjective marbling, and subjective firmness measured on the ventral surface and loin chop face were presented in Table 2. Significant correlations

Table 1. Summary statistics for aged pork quality assessed on the ventral surface and on loin chops ($n = 154$ pork loins)

Variable	Mean	Standard Deviation	Minimum	Maximum
Ventral Surface Assessment				
Subjective color	2.00	0.70	1.00	3.00
Minolta L^*	57.24	3.25	47.95	63.87
Minolta a^*	5.84	1.57	2.06	10.29
Minolta b^*	14.77	1.26	11.71	17.61
Subjective marbling	2.16	0.83	1.00	4.00
Subjective firmness	1.88	0.63	1.00	3.00
Loin Chop Assessment				
Subjective color	2.29	0.77	1.00	4.00
Minolta L^*	58.43	3.37	48.03	67.61
Minolta a^*	4.93	1.55	1.01	8.97
Minolta b^*	14.42	1.22	11.61	17.28
Subjective marbling	2.10	0.96	1.00	6.00
Subjective firmness	1.83	0.65	1.00	3.00
Additional Assessment				
pH	5.51	0.08	5.29	6.10
Purge loss, %	2.40	1.29	0.16	6.42
Foodscan intramuscular fat content (IMF), %	2.93	1.29	1.29	9.84
Cooking loss (endpoint cooking temperature = 63°C), %	13.61	3.48	7.56	25.80
Cooking loss (endpoint cooking temperature = 71°C), %	19.28	2.95	12.75	27.90
Warner-Bratzler shear force (endpoint cooking temperature = 63°C), kg	1.71	0.35	0.92	2.82
Warner-Bratzler shear force (endpoint cooking temperature = 71°C), kg	2.05	0.49	1.14	3.85

Table 2. Pearson correlation coefficients for aged pork quality assessed on the ventral surface and on loin chops ($n = 154$ pork loins)[a]

Variable	Ventral Surface Subjective Color	Ventral Surface Minolta L^*	Ventral Surface Minolta a^*	Ventral Surface Minolta b^*	Ventral Surface Subjective Marbling	Ventral Surface Subjective Firmness
Loin Chop Subjective Color	**0.69** (<0.01)	**−0.31** (<0.01)	**0.48** (<0.01)	**0.25** (<0.01)	**0.24** (<0.01)	**−0.25** (<0.01)
Loin Chop Minolta L^*	**−0.53** (<0.01)	**0.42** (<0.01)	**−0.20** (0.01)	0.02 (0.76)	−0.14 (0.09)	0.12 (0.14)
Loin Chop Minolta a^*	**0.34** (<0.01)	**−0.01** (0.92)	**0.65** (<0.01)	**0.50** (<0.01)	**0.30** (<0.01)	−0.05 (0.55)
Loin Chop Minolta b^*	0.02 (0.81)	0.13 (0.11)	**0.43** (<0.01)	**0.45** (<0.01)	0.11 (0.17)	−0.02 (0.77)
Loin Chop Subjective Marbling	0.14 (0.09)	0.10 (0.22)	**0.29** (<0.01)	**0.30** (<0.01)	**0.58** (<0.01)	**0.16** (0.05)
Loin Chop Subjective Firmness	−0.13 (0.11)	**0.22** (0.01)	**−0.16** (0.05)	0.05 (0.51)	**0.17** (0.04)	**0.20** (0.01)

[a]The upper row is the correlation coefficient between traits; bold values indicate significant correlations; the lower row is the P value representing the difference from zero.

were present for the same measurements collected on the ventral surface and the loin chop face; however, the strength of the correlations ranged from strong correlations to weak correlations. Subjective color measured on the ventral surface and loin chop face was strongly correlated ($r = 0.69$; $P < 0.01$), instrumental color readings measured on the ventral surface and loin chop face were moderately correlated (Minolta L^*: $r = 0.42$; $P < 0.01$; Minolta a^*: $r = 0.65$; $P < 0.01$; Minolta b^*: $r = 0.45$; $P < 0.01$), subjective marbling measured on the ventral surface and loin chop face was moderately correlated ($r = 0.58$; $P < 0.01$), and subjective firmness measured on the ventral surface and loin chop was weakly correlated ($r = 0.20$; $P = 0.01$).

Pearson correlation coefficients for subjective color, instrumental color (L^*, a^*, and b^*), subjective marbling, and subjective firmness measured on the ventral surface, and additional assessments (pH, purge loss, IMF, cooking loss, and WBSF) were presented in Table 3. Significant correlations ($P < 0.05$) were present between a number of attributes; however, no correlation values were deemed as strong and the only correlation values deemed moderate in strength were found between ventral surface Minolta L^* and WBSF when chops were cooked to an endpoint temperature of 71°C ($r = 0.42$; $P < 0.01$) and between ventral surface subjective marbling and IMF ($r = 0.54$; $P < 0.01$).

Table 3. Pearson correlation coefficients for aged pork quality assessed on the ventral surface and additional assessment parameters ($n = 154$ pork loins)[a]

Variable	Ventral Surface Subjective Color	Ventral Surface Minolta L^*	Ventral Surface Minolta a^*	Ventral Surface Minolta b^*	Ventral Surface Subjective Marbling	Ventral Surface Subjective Firmness
pH	0.11 (0.18)	**−0.23** (<0.01)	**−0.17** (0.04)	**−0.20** (0.02)	0.06 (0.43)	0.03 (0.71)
Purge loss, %	**−0.18** (0.03)	0.07 (0.38)	−0.12 (0.14)	−0.12 (0.14)	**−0.17** (0.04)	−0.04 (0.66)
Foodscan intramuscular fat content (IMF), %	**0.17** (0.03)	**0.28** (<0.01)	0.12 (0.14)	**0.26** (<0.01)	**0.54** (<0.01)	**0.35** (<0.01)
Cooking loss (endpoint cooking temperature = 63°C), %	**−0.23** (0.01)	**0.27** (<0.01)	**−0.35** (<0.01)	**−0.16** (0.05)	**−0.15** (0.07)	0.10 (0.22)
Cooking loss (endpoint cooking temperature = 71°C), %	**−0.17** (0.04)	0.01 (0.94)	−0.15 (0.07)	−0.13 (0.11)	**−0.32** (<0.01)	**−0.20** (0.01)
Warner-Bratzler shear force (endpoint cooking temperature = 63°C), kg	**0.25** (<0.01)	−0.04 (0.59)	0.05 (0.53)	0.01 (0.91)	**0.17** (0.04)	−0.02 (0.76)
Warner-Bratzler shear force (endpoint cooking temperature = 71°C), kg	**0.21** (0.01)	**−0.42** (<0.01)	**0.28** (<0.01)	−0.06 (0.45)	0.01 (0.91)	**−0.18** (0.02)

[a]The upper row is the correlation coefficient between traits; bold values indicate significant correlations; the lower row is the P-value representing the difference from zero.

Table 4. Pearson correlation coefficients for aged pork quality assessed on loin chops and additional assessment parameters ($n = 154$ pork loins)[a]

Variable	Loin Chop Subjective Color	Loin Chop Minolta L^*	Loin Chop Minolta a^*	Loin Chop Minolta b^*	Loin Chop Subjective Marbling	Loin Chop Subjective Firmness
pH	−0.01 (0.87)	−0.15 (0.07)	**−0.23** (<0.01)	**−0.20** (0.01)	−0.03 (0.72)	−0.05 (0.52)
Purge loss, %	**−0.16** (0.04)	0.05 (0.57)	−0.08 (0.31)	−0.11 (0.18)	**−0.23** (<0.01)	0.02 (0.76)
Foodscan intramuscular fat content (IMF), %	−0.12 (0.13)	**0.27** (<0.01)	0.11 (0.19)	**0.16** (0.05)	**0.73** (<0.01)	**0.27** (<0.01)
Cooking loss (endpoint cooking temperature = 63°C), %	**−0.32** (<0.01)	**0.16** (0.05)	**−0.22** (0.01)	−0.13 (0.11)	**−0.27** (<0.01)	0.07 (0.39)
Cooking loss (endpoint cooking temperature = 71°C), %	−0.13 (0.11)	0.09 (0.29)	**−0.20** (0.01)	−0.15 (0.07)	**−0.38** (<0.01)	−0.05 (0.55)
Warner-Bratzler shear force (endpoint cooking temperature = 63°C), kg	**0.26** (<0.01)	**−0.36** (<0.01)	0.11 (0.18)	−0.09 (0.26)	0.06 (0.43)	0.06 (0.43)
Warner-Bratzler shear force (endpoint cooking temperature = 71°C), kg	**0.32** (<0.01)	**−0.35** (<0.01)	0.13 (0.11)	−0.06 (0.45)	0.10 (0.20)	−0.02 (0.78)

[a]The upper row is the correlation coefficient between traits; bold values indicate significant correlations; the lower row is the P-value representing the difference from zero.

Pearson correlation coefficients for subjective color, instrumental color (L^*, a^*, and b^*), subjective marbling, and subjective firmness measured on the loin chop and additional assessments (pH, purge loss, IMF, cooking loss, and WBSF) were presented in Table 4. Significant correlations ($P < 0.05$) were present between a number of attributes; however, the only correlation values deemed moderate or strong in their strength were found between loin chop Minolta L^* and WBSF when chops were cooked to an endpoint temperature of 63°C (r = −0.36; $P < 0.01$), between loin chop subjective marbling and IMF (r = 0.73; $P < 0.01$), and between loin chop subjective marbling and cooking loss when chops were cooked to an endpoint temperature of 71°C (r = −0.38; $P < 0.01$).

Regression analysis

Multiple regression models reveal the unique, controlled, and combined effects of multiple predictors on an outcome, whereas correlation only describes pairwise associations without accounting for confounding or shared variance. For this study, loin chop quality and IMF (measured with the Foodscan) served as the dependent variable in the models, and the independent variables were ventral surface quality parameters when loin chop quality parameters served as the dependent variables, and both ventral surface and loin chop quality parameters when IMF served as the dependent variable. The purpose of organizing the models in this way was to determine the ability of ventral edge quality to predict specific loin chop quality parameters, and for all of the quality assessments to predict the objective measure of IMF.

The multiple regression models revealed 53.1% of the variation for loin chop subjective color was explained with ventral surface subjective color (partial $R^2 = 0.47$; $P < 0.01$) and ventral surface Minolta a^* (partial $R^2 = 0.06$; $P < 0.01$) (Table 5); 38.8% of the variation for loin chop Minolta L^* was explained with

Table 5. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict loin chop subjective color using ventral surface quality assessment (subjective color, Minolta L^*, Minolta a^*, Minolta b^*, subjective marbling, and subjective firmness) and additional assessment parameters (pH, purge loss, and intramuscular fat)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	F Value	Pr > F
1	Ventral Surface Subjective Color	1	0.47	0.47	19.95	135.36	<0.01
2	Ventral Surface Minolta a^*	2	0.06	0.53	3.72	18.15	<0.01

[a]Regression model equation: Loin chop subjective color = 0.2148 + (ventral surface subjective color × 0.06574) + (ventral surface Minolta a^* × 0.1291).

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

ventral surface subjective color (partial $R^2 = 0.27$; $P < 0.01$), ventral surface Minolta L^* (partial $R^2 = 0.06$; $P < 0.01$), IMF (partial $R^2 = 0.02$; $P = 0.04$), and ventral surface subjective marbling (partial $R^2 = 0.04$; $P < 0.01$) (Table 6); 51.2% of the variation for loin chop Minolta a^* was explained with ventral surface Minolta a^* (partial $R^2 = 0.42$; $P < 0.01$), ventral surface subjective marbling (partial $R^2 = 0.04$; $P < 0.01$), pH (partial $R^2 = 0.02$; $P = 0.01$), IMF (partial $R^2 = 0.02$; $P = 0.05$), and ventral surface Minolta L^* (partial $R^2 = 0.01$; $P = 0.05$) (Table 7); 24.5% of the variation for loin chop Minolta b^* was explained with ventral surface Minolta b^* (partial $R^2 = 0.19$; $P < 0.01$), ventral surface Minolta a^*(partial $R^2 = 19$; $P < 0.01$), and ventral surface Minolta L^* (partial $R^2 = 0.02$; $P = 0.04$) (Table 8); 65.0% of the variation for loin chop subjective marbling was explained with IMF (partial $R^2 = 0.54$; $P < 0.01$), ventral surface subjective color (partial $R^2 = 0.08$; $P < 0.01$), ventral surface marbling (partial $R^2 = 0.02$; $P = 0.02$), and ventral surface Minolta a^* (partial $R^2 = 0.01$; $P = 0.02$) (Table 9); 72.5% of the variation for IMF was explained with loin chop subjective marbling (partial $R^2 = 0.54$; $P < 0.01$), loin chop Minolta L^* (partial $R^2 = 0.11$; $P < 0.01$), ventral surface subjective firmness (partial $R^2 = 0.04$; $P < 0.01$), ventral surface subjective marbling (partial $R^2 = 0.02$; $P < 0.01$), and ventral surface subjective color (partial $R^2 = 0.02$; $P < 0.01$) (Table 10); and 13.9% of the variation for loin chop subjective firmness was explained with IMF (partial $R^2 = 0.07$; $P < 0.01$), ventral surface Minolta a^* (partial $R^2 = 0.05$; $P = 0.01$), and ventral surface Minolta b^* (partial $R^2 = 0.02$; $P = 0.05$) (Table 11).

Discussion

This study aimed to determine the prediction ability of pork loin chop quality when assessing quality on the ventral surface of loins or when using objective measurements of quality. Results from this study indicate that quality attributes assessed on the ventral surface of pork loins provide only moderate predictive

Table 6. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict loin chop Minolta L^* using ventral surface quality assessment (subjective color, Minolta L^*, Minolta a^*, Minolta b^*, subjective marbling, and subjective firmness) and additional assessment parameters (pH, purge loss, and intramuscular fat)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	F Value	Pr > F
1	Ventral Surface Subjective Color	1	0.27	0.27	25.97	55.32	<0.01
2	Ventral Surface Minolta L^*	2	0.06	0.33	13.31	13.72	<0.01
3	Foodscan intramuscular fat content (IMF), %	3	0.02	0.35	10.76	4.35	0.04
4	Ventral Surface Subjective Marbling	4	0.04	0.39	3.83	8.99	<0.01

[a]Regression model equation: Loin chop Minolta $L^* = 45.08 - (\text{ventral surface subjective color} \times 1.441) + (\text{ventral surface Minolta } L^* \times 0.2847) + (\text{Foodscan IMF} \times 0.7766) - (\text{ventral surface subjective marbling} \times 1.081)$.

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

Table 7. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict loin chop Minolta a^* using ventral surface quality assessment (subjective color, Minolta L^*, Minolta a^*, Minolta b^*, subjective marbling, and subjective firmness) and additional assessment parameters (pH, purge loss, and intramuscular fat)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	F Value	Pr > F
1	Ventral Surface Minolta a^*	1	0.42	0.42	24.22	108.55	<0.01
2	Ventral Surface Subjective Marbling	2	0.04	0.46	13.10	12.29	<0.01
3	pH	3	0.02	0.48	8.80	6.10	0.01
4	Foodscan intramuscular fat content (IMF), %	4	0.02	0.50	6.85	3.89	0.05
5	Ventral Surface Minolta L^*	5	0.01	0.51	4.82	4.07	0.05

[a]Regression model equation: Loin chop Minolta $a^* = 7.522 + (\text{ventral surface Minolta } a^* \times 0.6336) + (\text{ventral surface subjective marbling} \times 0.5408) - (\text{pH} \times 1.905) - (\text{Foodscan IMF} \times 0.2115) + (\text{ventral surface Minolta } L^* \times 0.0638)$.

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

Table 8. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict loin chop Minolta *b** using ventral surface quality assessment (subjective color, Minolta *L**, Minolta *a**, Minolta *b**, subjective marbling, and subjective firmness) and additional assessment parameters (pH, purge loss, and intramuscular fat)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	*F* Value	Pr > *F*
1	Ventral Surface Minolta *b**	1	0.19	0.19	7.89	35.97	<0.01
2	Ventral Surface Minolta *a**	2	0.03	0.22	4.05	5.80	0.02
3	Ventral Surface Minolta *L**	3	0.02	0.24	1.89	4.23	0.04

[a]Regression model equation: Loin chop Minolta *b** = 6.670 + (ventral surface Minolta *b** × 0.0479) + (ventral surface Minolta *a** × 0.3556) + (ventral surface Minolta *L** × 0.0863).

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

Table 9. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict loin chop subjective marbling using ventral surface quality assessment (subjective color, Minolta *L**, Minolta *a**, Minolta *b**, subjective marbling, and subjective firmness) and additional assessment parameters (pH, purge loss, and intramuscular fat)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	*F* Value	Pr > *F*
1	Foodscan Intramuscular Fat Content	1	0.54	0.54	44.01	178.23	<0.01
2	Ventral Surface Subjective Color	2	0.08	0.62	11.90	32.18	<0.01
3	Ventral Surface Subjective Marbling	3	0.02	0.64	8.46	5.29	0.02
4	Ventral Surface Minolta *a**	4	0.01	0.65	4.88	5.59	0.02

[a]Regression model equation: Loin chop subjective marbling = −0.7398 + (Foodscan IMF × 0.5018) + (ventral surface subjective color × 0.2478) + (ventral surface subjective marbling × 1.963) + (ventral surface Minolta *a** × 0.0802).

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

Table 10. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict Foodscan intramuscular fat content (IMF) using ventral surface quality assessment (subjective color, Minolta *L**, Minolta *a**, Minolta *b**, subjective marbling, and subjective firmness), loin chop quality assessment (subjective color, Minolta *L**, Minolta *a**, Minolta *b**, subjective marbling, and subjective firmness), and additional assessment parameters (pH and purge loss)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	*F* Value	Pr > *F*
1	Loin Chop Subjective Marbling	1	0.54	0.54	93.65	178.23	<0.01
2	Loin Chop Minolta *L**	2	0.11	0.65	40.75	43.80	<0.01
3	Ventral Surface Subjective Firmness	3	0.04	0.69	22.69	17.81	<0.01
4	Ventral Surface Subjective Marbling	4	0.02	0.71	14.70	9.38	<0.01
5	Ventral Surface Subjective Color	5	0.02	0.73	5.59	11.14	<0.01

[a]Regression model equation: IMF = −4.59022 + (loin chop subjective marbling × 0.82534) − (loin chop Minolta *L** × 0.33597) + (ventral surface subjective firmness × 0.24186) + (ventral surface subjective marbling × 0.34906) − (ventral surface subjective color × 0.33597).

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

ability for quality characteristics of center-cut chops. While several ventral surface measurements were significantly associated with loin chop quality traits, the strength of these relationships suggests that ventral surface evaluation alone is insufficient for accurately predicting center-cut chop quality.

These findings align with previous research conducted on this topic, evaluating the association between ventral surface quality attributes and loin chop quality attributes, both when postmortem aging occurred between measurements and when postmortem aging did not occur between measurements.

Table 11. Summary of stepwise selection of independent variables using the regression procedure of SAS to predict loin chop subjective firmness using ventral surface quality assessment (subjective color, Minolta L^*, Minolta a^*, Minolta b^*, subjective marbling, and subjective firmness) and additional assessment parameters (pH, purge loss, and intramuscular fat)[a,b]

Step	Variable Entered	Number of Variables Included	Partial R^2	Model R^2	C(p)	*F* Value	Pr > *F*
1	Foodscan Intramuscular Fat Content	1	0.07	0.07	9.68	11.49	<0.01
2	Ventral Surface Minolta a^*	2	0.05	0.12	3.95	7.68	0.01
3	Ventral Surface Minolta b^*	3	0.02	0.14	2.10	3.90	0.05

[a]Regression model equation: Loin chop subjective firmness = 0.6949 + (Foodscan IMF × 0.1283) − (ventral surface Minolta a^* × 0.1491) + (ventral surface Minolta b^* × 0.1109).

[b]The option SLENTRY = 0.15 (specifies that a variable should be significant at the 0.15 level before it can be entered into the model) was used to generate the regression model.

Harsh et al. (2018) reported moderate or weak correlation between ventral surface measurements on d-1 postmortem with aged (12 to 28 d postmortem) loin chop quality traits (subjective color: r = 0.43; Minolta L^*: r = 0.44; Minolta a^*: r = 0.46; Minolta b^*: r = 0.27; subjective marbling: r = 0.56; extractable IMF: r = 0.69; subjective firmness: r = 0.09). Interestingly, Harsh et al. (2018) reported moderate or weak correlation between ventral surface measurements on d-1 postmortem with aged (12 to 28 d postmortem) ventral surface measurements (subjective color: r = 0.50; Minolta L^*: r = 0.50; Minolta a^*: r = 0.49; Minolta b^*: r = 0.33; subjective marbling: r = 0.63; extractable IMF: r = 0.62; subjective firmness: r = 0.26). Furthermore, Lowell et al. (2017) reported moderate correlation between early postmortem (day 1 postmortem) color, and marbling were moderately correlated with aged (day 14 postmortem) ventral loin color and marbling, and weakly correlated with aged loin chop color and marbling. Collectively, findings from Harsh et al. (2018) and Lowell et al. (2017) suggest that postmortem aging, as well as environmental differences between early and aged evaluations, may influence the predictive ability of ventral surface measurements. In addition, antemortem and early postmortem factors such as stunning method and chilling rate are well-established contributors to variation in pork quality (Sionek and Przybylski, 2016; Zybert et al., 2019; Zybert, 2022; Chen et al., 2025). Stunning and chilling practices influence pH decline, temperature dynamics, and subsequent color and water-holding capacity, which may further contribute to variability between ventral surface assessments and center-cut chop characteristics. In the current study, electrical stunning and conventional chilling (20–24 h of exposure to ambient temperatures of approximately 2°C) were used—future investigation should be conducted on the predictive ability of ventral surface measurements for pork loins from pigs stunned with CO_2 and blast chilled.

To our knowledge, there are only 2 studies that have evaluated the association between ventral surface quality and chop face quality at the same time in the same environmental conditions. Uttaro et al. (2021) explored an image analysis method to identify marbling on the ventral surface of pork loins (aged 1 to 3 d postmortem). In this study, the authors reported a strong correlation (r = 0.86) between marbling of the center-cut loin chops evaluated with image analysis and IMF of the center-cut loin chops evaluated with extractable lipid. Wei et al. (2024) explored an image analysis method to identify color on the ventral surface of pork loins (aged 1 to 3 d postmortem). In this study, the authors reported a strong correlation (r = 0.79) between color classification (using image analysis) of the ventral surface and center-cut loin chops, while weak correlations (r < 0.30) were reported between color classification (using image analysis) of the ventral surface and the anterior end or the posterior end. The limitation of these studies, as related to the objectives of the current study, was that image analysis was used rather than subjective evaluation.

Specific to the location of the evaluations, several studies have reported divergent levels of IMF throughout the *longissimus* muscle. Mandell et al. (2006) reported that Minolta L^* ranged as much as 3.3 units and IMF ranged as much as 1.1% when comparing center-cut loin chops with loin chops from the anterior or posterior ends. Redifer et al. (2020) reported similar findings with subjective color ranging as much as 0.40 units, subjective marbling ranging as much as 0.74 units, subjective firmness ranging as much as 1.16 units, and IMF ranging as much as 1.03%, depending on chop location. Collectively, these studies demonstrate that evaluation location along the *longissimus* muscle substantially influences both visual quality traits and

IMF, underscoring meaningful within-muscle variability from anterior to posterior regions.

Results from the current study, in combination with previously published literature, indicate that evaluating quality attributes on the ventral surface of pork loins provides only limited to moderate insight into the quality characteristics of center-cut loin chops. Although significant associations were observed, the magnitude of these relationships suggests that ventral surface assessments—particularly when conducted subjectively—are not sufficient as a standalone tool for accurately predicting loin chop quality. Differences in postmortem aging, environmental conditions at evaluation, and measurement methodology appear to further influence prediction ability. Collectively, these findings highlight the need for incorporating objective measurements or advanced technologies, such as image analysis, alongside traditional ventral surface evaluations to improve the accuracy and consistency of predicting center-cut pork loin chop quality.

Conclusion

Correlation and regression analyses demonstrated that ventral surface quality traits were significantly associated with loin chop quality and IMF, but these relationships were generally weak to moderate in strength. Together, these results indicate that ventral surface evaluations alone have limited predictive power for center-cut loin chop quality and are most informative when combined with objective measurements or other assessments collected on the loin chop.

Conflict of Interest

The authors declare no conflicts of interest.

Acknowledgments

This study was partially funded by the Internal Grant Program of the College of Food, Agricultural, and Environmental Sciences at The Ohio State University.

Author Contribution

Yifei Wang: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing.

Rebecca A. Brown: Investigation

Milena Conte: Investigation

Benjamin M. Bohrer: Conceptualization, Data curation, Methodology, Investigation, Supervision, Funding acquisition, Project administration, Writing – review & editing.

Literature Cited

Chen, X., B. Valente, N. Matthews, L. C. Eastwood, A. Sosnicki, and B. Fields. 2025. Prediction of pork loin quality using postmortem temperature and pH decline curves. Meat Muscle Biol. 9:18416. https://doi.org/10.22175/mmb.18416

Harsh, B. N., D. D. Boler, S. D. Shackelford, and A. C. Dilger. 2018. Determining the relationship between early postmortem loin quality attributes and aged loin quality attributes using meta-analyses techniques. J. Anim. Sci. 96:3161–3172. https://doi.org/10.1093/jas/sky183

Mandell, I. B., C. P. Campbell, and C. F. de Lange. 2006. Effects of gender, sire line, and penning environment on growth, carcass characteristics, and aspects of pork meat quality at different locations in the loin. Can. J. Anim. Sci. 86:49–61. https://doi.org/10.4141/A05-025

Lowell, J. E., M. F. Overholt, B. N. Harsh, C. A. Stahl, A. C. Dilger, and D. D. Boler. 2017. Relationships among early postmortem loin quality and aged loin and pork chop quality characteristics between barrows and gilts. Transl. Anim. Sci. 1:607–619. https://doi.org/10.2527/tas2017.0074

National Pork Producers Council (NPPC). 1991. Procedures to evaluate market hogs. 3rd ed. NPPC, Des Moines, IA.

National Pork Producers Council (NPPC). 1999. Official color and marbling standards. NPPC, Des Moines, IA.

Redifer, J. D., J. E. Beever, C. A. Stahl, D. D. Boler, and A. C. Dilger. 2020. Characterizing the amount and variability of intramuscular fat deposition throughout pork loins using barrows and gilts from two sire lines. J. Anim. Sci. 98:skaa275. https://doi.org/10.1093/jas/skaa275

Schulte, M. D., L. G. Johnson, E. A. Zuber, B. M. Patterson, A. C. Outhouse, C. A. Fedler, E. M. Steadham, D. A. King, K. J. Prusa, E. Huff-Lonergan, and S. M. Lonergan. 2019. Influence of postmortem aging and post-aging freezing on pork loin quality attributes. Meat Muscle Biol. 3:313–323. https://doi.org/10.22175/mmb2019.05.0015

Sionek, B., and W. Przybylski. 2016. The impact of ante-and postmortem factors on the incidence of pork defective meat-a review. Annu. Anim. Sci. 16(2): 333–345. https://doi.org/10.1515/aoas-2015-0086

Taylor, R. 1990. Interpretation of the correlation coefficient: a basic review. J. Diagn. Med. Sonogr. 6(1), 35–39. https://doi.org/10.1177/875647939000600106

Uttaro, B., S. Zawadski, I. Larsen, and M. Juárez. 2021. An image analysis approach to identification and measurement of marbling in the intact pork loin. Meat Sci. 179, 108549. https://doi.org/10.1016/j.meatsci.2021.108549

Uttaro, B., S. Zawadski, and M. Juárez. 2025. Exploring the relationship of colour categorization with pork colour standards under different subjective and objective conditions. Meat Sci. 219:109661. https://doi.org/10.1016/j.meatsci.2024.109661

Wei, X., B. Bohrer, B. Uttaro, and M. Juárez. 2023. Centre pork chop colour classification using image analysis on the ventral surface of the loin. Can. J. Anim. Sci. 104:123–126. https://doi.org/10.1139/cjas-2023-0011

Zybert, A., K. Tarczy ski, and H. Sieczkowska. 2019. Meta-analysis of the effect of chilling on selected attributes of fresh pork. J. Food Process. Preserv. 43:e14061. https://doi.org/10.1111/jfpp.14061

Zybert, A. 2022. Quantification of the effects of electrical and CO_2 stunning on selected quality attributes of fresh pork: a meta-analysis. Animals 12:1811. https://doi.org/10.3390/ani12141811

Supplementary Table 1. Prediction accuracy for loin chop subjective color using ventral surface subjective color

Variable	Loin Chop Subjective Color Score 1	Loin Chop Subjective Color Score 2	Loin Chop Subjective Color Score 3	Loin Chop Subjective Color Score 4
Ventral Surface Color Score 1	**81.5% (22/27)**	25.4% (15/59)	0.0% (0/65)	0.0% (0/3)
Ventral Surface Color Score 2	18.5% (5/27)	**66.1% (39/59)**	55.4% (36/65)	0.0% (0/3)
Ventral Surface Color Score 3	0.0% (0/27)	8.5% (5/59)	**44.6% (29/65)**	100.0% (3/3)
Ventral Surface Color Score 4	0.0% (0/27)	0.0% (0/59)	0.0% (0/65)	**0.0% (0/3)**

Supplementary Table 2. Prediction accuracy for loin chop Minolta *L** using ventral surface Minolta *L**

Variable	Loin Chop Minolta *L** value of < 52	Loin Chop Minolta *L** value of 52 to 55	Loin Chop Minolta *L** value of 55 to 58	Loin Chop Minolta *L** value of 58 to 61	Loin Chop Minolta *L** value of 61 to 64	Loin Chop Minolta *L** value of > 64
Ventral Surface Minolta *L** value of < 52	**66.7% (2/3)**	11.7% (2/17)	7.3% (4/55)	4.7% (2/42)	0.0% (0/26)	0.0% (0/11)
Ventral Surface Minolta *L** value of 52 to 55	33.3% (1/3)	**29.4% (5/17)**	21.8% (12/55)	16.7% (7/42)	3.8% (1/26)	9.1% (1/11)
Ventral Surface Minolta *L** value of 55 to 58	0.0% (0/3)	35.3% (6/17)	**41.8% (23/55)**	38.1% (16/42)	15.4% (4/26)	27.3% (3/11)
Ventral Surface Minolta *L* of 58 to 61	0.0% (0/3)	17.7% (3/17)	21.8% (12/55)	**31.0% (13/42)**	57.7% (15/26)	36.3% (4/11)
Ventral Surface Minolta *L* value of 61 to 64	0.0% (0/3)	5.9% (1/17)	7.3% (4/55)	9.5% (4/42)	**23.1% (6/26)**	27.3% (3/11)
Ventral Surface Minolta *L* value of > 64	0.0% (0/3)	0.0% (0/17)	0.0% (0/55)	0.0% (0/42)	0.0% (0/26)	**0.0% (0/11)**

Supplementary Table 3. Prediction accuracy for loin chop Minolta *a** using ventral surface Minolta *a**

Variable	Loin Chop Minolta *a** value of < 2.5	Loin Chop Minolta *a** value of 2.5 to 5.0	Loin Chop Minolta *a** value of 5.0 to 7.5	Loin Chop Minolta *a** value of > 7.5
Ventral Surface Minolta *a** value of < 2.5	**23.0% (3/13)**	0.0% (0/70)	0.0% (0/63)	0.0% (0/8)
Ventral Surface Minolta *a** value of 2.5 to 5.0	38.5% (5/13)	**41.5% (29/70)**	11.1% (7/63)	0.0% (0/8)
Ventral Surface Minolta *a** value of 5.0 to 7.5	38.5% (5/13)	57.1% (40/70)	**65.1% (41/63)**	37.5% (3/8)
Ventral Surface Minolta *a** value of > 7.5	0.0% (0/13)	1.4% (1/70)	23.8% (15/63)	**62.5% (5/8)**

Supplementary Table 4. Prediction accuracy for loin chop Minolta *b** using ventral surface Minolta *b**

Variable	Loin Chop Minolta *b** value of < 12.0	Loin Chop Minolta *b** value of 12.0 to 14.0	Loin Chop Minolta *b** value of 14.0 to 16.0	Loin Chop Minolta *b** value of > 16.0
Ventral Surface Minolta *b** value of < 12.0	**0.0% (0/5)**	1.9% (1/53)	1.2% (1/86)	0.0% (0/10)
Ventral Surface Minolta *b** value of 12.0 to 14.0	20.0% (1/5)	**54.7% (29/53)**	15.1% (13/86)	0.0% (0.10)
Ventral Surface Minolta *b** value of 14.0 to 16.0	80.0% (4/5)	35.9% (19/53)	**62.8% (54/86)**	80.0% (8/10)
Ventral Surface Minolta *b** value of > 16.0	0.0% (0/5)	7.5% (4/53)	20.9% (18/86)	**20.0% (2/10)**

Supplementary Table 5. Prediction accuracy for loin chop subjective marbling using ventral surface subjective marbling

Variable	Loin Chop Subjective Marbling Score 1	Loin Chop Subjective Marbling Score 2	Loin Chop Subjective Marbling Score 3	Loin Chop Subjective Marbling Score ≥ 4
Ventral Surface Marbling Score 1	**46.3% (19/41)**	16.7% (12/72)	3.2% (1/31)	0.0% (0/10)
Ventral Surface Marbling Score 2	43.9% (18/41)	**63.9% (46/72)**	35.5% (11/31)	10.0% (1/10)
Ventral Surface Marbling Score 3	9.8% (4/41)	18.1% (13/72)	**45.2% (14/31)**	50.0% (5/10)
Ventral Surface Marbling Score ≥ 4	0.0% (0/41)	1.4% (1/72)	16.1% (5/31)	**40.0% (4/10)**

Supplementary Table 6. Prediction accuracy for loin chop subjective firmness using ventral surface subjective firmness

Variable	Loin Chop Subjective Firmness Score 1	Loin Chop Subjective Firmness Score 2	Loin Chop Subjective Firmness Score 3
Ventral Surface Firmness Score 1	**39.6% (19/48)**	20.2% (17/84)	22.7% (5/22)
Ventral Surface Firmness Score 2	50.0% (24/48)	**66.7% (56/84)**	45.5% (10/22)
Ventral Surface Firmness Score 3	10.4% (5/48)	13.1% (11.84)	**31.8% (7/22)**