ON-LINE PREDICTION OF PORK LOIN QUALITY WITH THE VQG PORK LOIN GRADING CAMERA

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Abstract – The present study was conducted to evaluate the ability of the Vision Quality Grading (VQG) pork loin grading camera to predict pork loin quality traits under current industrial conditions. In 7 sampling trips (n = 6 packing plants) across the United States, VQG analysis was conducted at 1 day postmortem (dpm) on 1400 loins. Objective color, subjective color and marbling, pH, purge loss and cook loss data were collected. Loins were divided into odd and even numbered groups. Odd numbered loins (n = 700) were assigned to a calibration data set that was used to develop regression equations, and even numbered loins (n = 700) were assigned to a prediction data set used to validate the regression equations. Noninvasive assessment of loin color, water-holding capacity and marbling made with the VQG immediately following loin boning and trimming were correlated to the observed respective measurements taken on the ventral side of the boneless pork loin at the time of cutting (1 dpm) and measurements taken on bloomed chops at 14 dpm. The VQG technology could be used as a noninvasive method by the pork industry to accurately assess pork color, water-holding capacity, and marbling.

Key Words – color, image, marbling

I. INTRODUCTION

Pork loin quality is influenced by a number of factors that include color, marbling, purge loss, cook loss and pH [1]. Visual assessment of boneless pork loin quality under industrial conditions is used in plants for segregation of product into programs and for export, as well as for routine quality control and research. This assessment is usually made on the exposed longissimus (LM) on the ventral side of the muscle. However, lighting and bloom time may not be ideal on-line at time of subjective evaluation. Grading cameras can accurately assess meat quality more consistently and reduce inherent variation in human subjective evaluation [2]. In order to consistently identify high quality meat that meets consumer demand, the beef industry has implemented the use of the VBG2000LED grading camera in many North American beef packing plants. Application of the VISNIR system camera to the ventral side of boneless loins proved to be successful in predicting pork quality traits [3]. Recent development of the VQG camera with the GIGE imaging system now allows for high-resolution imaging. It is therefore the objective of this study to evaluate the effectiveness of the VQG pork loin grading camera at predicting various traits that influence quality such as color, cook loss and marbling.

II. MATERIALS AND METHODS

Pork packing plants (n = 6) were identified that represent variation in factors that are known to impact meat quality. Trained personnel selected boneless loins (n = 200/sampling trip) during routine loin boning and trimming at 1 dpm. Image analysis of the exposed ventral side of the boneless LM using the VQG camera was conducted on-line. Subjective color and marbling (NPPC, 1997); and objective color using a Hunter Miniscan XE Plus colorimeter (HunterLab, Reston, VA) with a 25-mm port (Hunter Lab D65/10°; 2 readings/loin; averaged) and pH at two locations (1/3 and 2/3 length of loin; averaged) was evaluated on each loin. Loins were vacuum-packaged, boxed and transported under refrigeration (2°C). Immediately upon arrival, loins were unboxed, sorted, weighed (initial weight for purge loss determination), and aged (fat-side down) in a single layer on solid-shelf carts. At 14 dpm, boneless loins were unpackaged and allowed to drip dry before weighing to assess purge loss. Loins were then prepared for slicing with a Grasselli NSL 400 portion meat slicer. The posterior end of the loin (~4 cm-long) was removed by a straight cut perpendicular to the length of the loin at a point 5 cm posterior to the anterior tip of gluteus accessories. The anterior end of the loin was removed by a second cut made 396 mm anterior to the first cut leaving a 396-mm-long center-cut loin section that fits the width of the Grasselli NSL 400 portion meat slicer. This approach, maximized yield of chops with the highest proportion of their mass/cross-sectional area comprised of longissimus and excluded chops with a high proportion of their mass/cross-sectional area comprised of other muscles (spinalis dorsi, multifidus dorsi, gluteus medius, gluteus accessorius). Additionally, this approach standardized anatomical location of chop assignment across loins. Chops 5 and 6, which correspond approximately to the 11th rib region of the loin, were used for determination of slice shear force (SSF) (data not reported) and cooking loss. Immediately after chops were sliced to 2.54-cm-thickness and tagged, chops were weighed (initial weight for cooking loss determination). The following day (15 dpm), chops were cooked (71°C) with a belt grill, weighed to determine cooking loss, and SSF determined (data not reported). Subjective color and marbling scores, objective color (Hunter Lab D65/10°; 2 readings/chop) and pH were determined for both chops 3 (anterior) and 10 (posterior) after 3 h bloom time, and averaged for a composite value for each loin.

Statistical Analysis

One-half of the loins were assigned to a calibration data set, which was used to develop regression equations, and one-half of the loins were assigned to a prediction data set, which was used to validate the regression equations [4]. Specifically, odd and even numbered loins were assigned to the calibration and prediction data sets, respectively. Regression analysis was conducted for Hunter L* and subjective marbling score collected immediately after loin boning and trimming and for cooking loss. For each of the dependent variables, the pool of independent variables from the image analysis system was first reduced to 3,000 variables using the proc corr statement of SAS with options (rank noprob nosimple BEST=3000). Then, forward stepwise regression was conducted using the PROC STEPWISE procedure of SAS with SLENTRY = 0.05. This narrowed the pool of independent variables from 3,000 to 25, 43, and 29 for L*, marbling score, and cooking loss, respectively; but, some variables in those equations were not significant ($P > 0.05$). Backward stepwise (PROC STEPWISE with SLSTAY = 0.0001) was conducted using those variables. The resulting regression equations had 5 (Hunter L*), 14 (marbling score), and 17 (cooking loss) independent variables, each of which was highly significant ($P < 0.0001$). Those regression equations were used to predict related traits in both the calibration and prediction data sets.

III. RESULTS AND DISCUSSION

All observed correlations where highly significant ($P < 0.0001$). Noninvasive assessment of loin color made with the VQG immediately following loin boning and trimming was strongly correlated to objective and subjective color measurements taken on the ventral side of the boneless pork loin at the time of cutting (1 dpm) and measurements taken on bloomed chops at 14 dpm (Table 1). The equation, which was developed to predict Hunter colorimeter L* with the calibration data set was effective for the prediction data set suggesting that this equation is robust. For the prediction data set, the VQG camera predictions of loin L* were negatively correlated with subjective color scores of the loin at 1 dpm (r = -0.55) and bloomed chops at 14 dpm (r = -0.50). A positive correlation occurred between the VQG camera predictions of loin color and chop L* (r = 0.78) for the prediction data set.

Assessment of loin water-holding capacity made with the VQG immediately following loin boning and trimming was correlated to cooking loss, purge loss, and pH of loins at 1 dpm and chops at 14 dpm (Table 2). For the prediction data set, the VQG camera predictions of cooking loss were correlated with observed purge loss (r = 0.38). Moreover, negative correlations occurred between VQG camera predictions of cooking loss and loin pH and chops pH (r = -0.47, -0.36), respectively.

Table 1. Correlation of VQG predicted color (Hunter D65 L*) with observed objective and subjective color measurements taken on the ventral side of the boneless pork loin at the time of cutting (1 day post-mortem) and measurements taken on bloomed chops at 14 d post-mortem for the calibration (n = 700) and prediction (n = 700) data sets.

Measurement	Calibration	Prediction
Loin L*	0.92	0.90
Loin a*	-0.24	-0.25
Loin b*	0.77	0.66
Chops L*	0.77	0.78
Chops a*	-0.20	-0.19
Chops b*	0.44	0.41
Chops L* Anterior	0.72	0.73
Chops a* Anterior	-0.21	-0.21
Chops b* Anterior	0.40	0.37
Chops L* Posterior	0.71	0.72
Chops a* Posterior	-0.15	-0.14
Chops b* Posterior	0.41	0.39
Loin Color	-0.54	-0.55
Chops Color	-0.46	-0.50
Chops Color Anterior	-0.43	-0.49
Chops Color Posterior	-0.43	-0.46

Loin marbling assessment made with the VQG immediately following loin boning and trimming was correlated to observed marbling score of loins at 1 dpm and chops at 14 dpm (Table 3). The equation, which was developed to predict loin marbling at 1 dpm with the calibration data set was effective for the prediction data set. For the prediction data set, the VQG camera predictions of loin marbling were positively correlated with the chops marbling, chops marbling anterior and chops marbling posterior (r = 0.58, 0.58, 0.53), respectively.

Table 2. Correlation of VQG predicted cooking loss with observed cooking loss, purge loss, and pH for the calibration (n = 700) and prediction (n = 700) data sets.

Measurement	Calibration	Prediction
Cooking Loss, %	0.62	0.50
Purge Loss, %	0.44	0.38
Loin pH	-0.51	-0.47
Chops pH	-0.37	-0.36

Table 3. Correlation of VQG predicted marbling score with observed marbling score taken on the ventral side of the boneless pork loin at the time of cutting (1 day post-mortem) and observed marbling score taken on bloomed chops at 14 d post-mortem for the calibration (n = 700) and prediction (n = 700) data sets.

Measurement	Calibration	Prediction
Loin Marbling	0.74	0.66
Chops Marbling	0.66	0.58
Chops Marbling Anterior	0.67	0.58
Chops Marbling Posterior	0.58	0.53

Although there have been experiments using other imaging systems that assessed different exposed surfaces to predict quality in pork loins [3,5,6], this is the first study, to our knowledge, to use the VQG camera as an on-line system to predict pork quality attributes on the ventral side of pork loins at 1 dpm.

IV. CONCLUSION

The present experiment could facilitate a noninvasive tool to use at line speed in large pork processing facilities to predict color, marbling, cook loss, purge loss and pH in pork loins. This could result in the reduction of invasive and costly methods for chemical assessment of intramuscular fat and pH. If a method was in place to predict pork loin quality traits, higher quality pork could be marketed in a premium program.

ACKNOWLEDGEMENTS

This project was funded in part by the United States Pork Checkoff.

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