The MARC Beef Carcass Image Analysis System

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Introduction

At present, beef carcass value is a function of USDA quality grade, a subjective estimate of meat palatability, and USDA yield grade, a subjective estimate of carcass composition. Although "expert" calculated USDA yield grade is a relatively accurate predictor of carcass composition, the development of an objective system to predict beef carcass cutability has been an industry priority. In 1997, we (Shackelford et al., 1998) developed a system to predict beef carcass cutability based on image analysis of the 12th rib cross-section which was removed from carcasses for tenderness classification. The Agricultural Research Service entered into a cooperative research and development agreement with IBP, Inc. to adopt this technology for application directly to beef carcasses. The resulting MARC Beef Image Analysis System was designed to predict beef carcass value determining characteristics based on an image of the 12th rib cross-section that is used for quality and yield grading. The system was designed to be functional under industrial conditions without modification of conventional slaughter, dressing, trimming, and ribbing procedures.

Image Analysis Prediction of Carcass Grade Traits

Image Analysis

To evaluate the ability of this system to predict "expert" gold standard estimates of calculated yield grade, ribeye area, adjusted preliminary yield grade, and marbling score under commercial beef processing conditions, image analysis was conducted on the beef grading chain immediately after the conventional USDA beef quality and yield grades were applied at IBP's Lexington, NE and Amarillo, TX beef processing facilities. In each facility, 400 carcasses were evaluated by image analysis on the grading chain.

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Gold Standard Grades

After the image analysis process was completed, carcasses were transferred to stationary rails in regrade bays with ample lighting and space for "gold-standard" evaluation of quality and yield grade factors. For the imaged side of each carcass, 3 experts independently traced the outline of the ribeye onto acetate paper. Subsequently, each acetate tracing was digitized using a flatbed scanner and the ribeye area was measured in triplicate using image analysis. A team of 3 supervisory level personnel from the Standardization and Meat Grading branches of the Livestock and Seed Division of USDA-AMS determined actual preliminary yield grade (measured on the side that was imaged), adjusted preliminary yield grade, kidney, pelvic, and heart fat percentage, marbling score, dark-cutting discount (if applicable), skeletal, lean, and overall maturity, and quality grade. As with conventional quality grading, marbling score was recorded for the side of the carcass with the highest degree of marbling.

Statistics

Carcasses were blocked by plant and observed calculated yield grade and one-half of the carcasses were assigned to a calibration data set, which was used to develop regression equations, and one-half of the carcasses were assigned to a prediction data set, which was used to validate the regression equations (Neter et al., 1989). Regression equations were developed using two sets of independent variables. The first set included image analysis traits and HCW. The second set only included image analysis traits.

Prediction of Yield Grade

A four-variable regression equation that included HCW and image analysis variables accounted for 90% of the variation in yield grade in both the calibration and prediction data sets (Figure 1). A four-variable regression equation that included only image analysis variables accounted for 84% and 86% of the variation in yield grade in the calibration and prediction data sets, respectively. Belk et al. (1997) proposed a system where an instrument would be used to measure longissimus area, on-line USDA graders would assess carcass fatness, and yield grade would be calculated using a computer. Steiner et al. (2000) reported that such a system could account for 81% or 74% of the variation in "expert" yield grade if ribeye area was measured by CVS or VIAscan™, respectively. Thus, it ap-

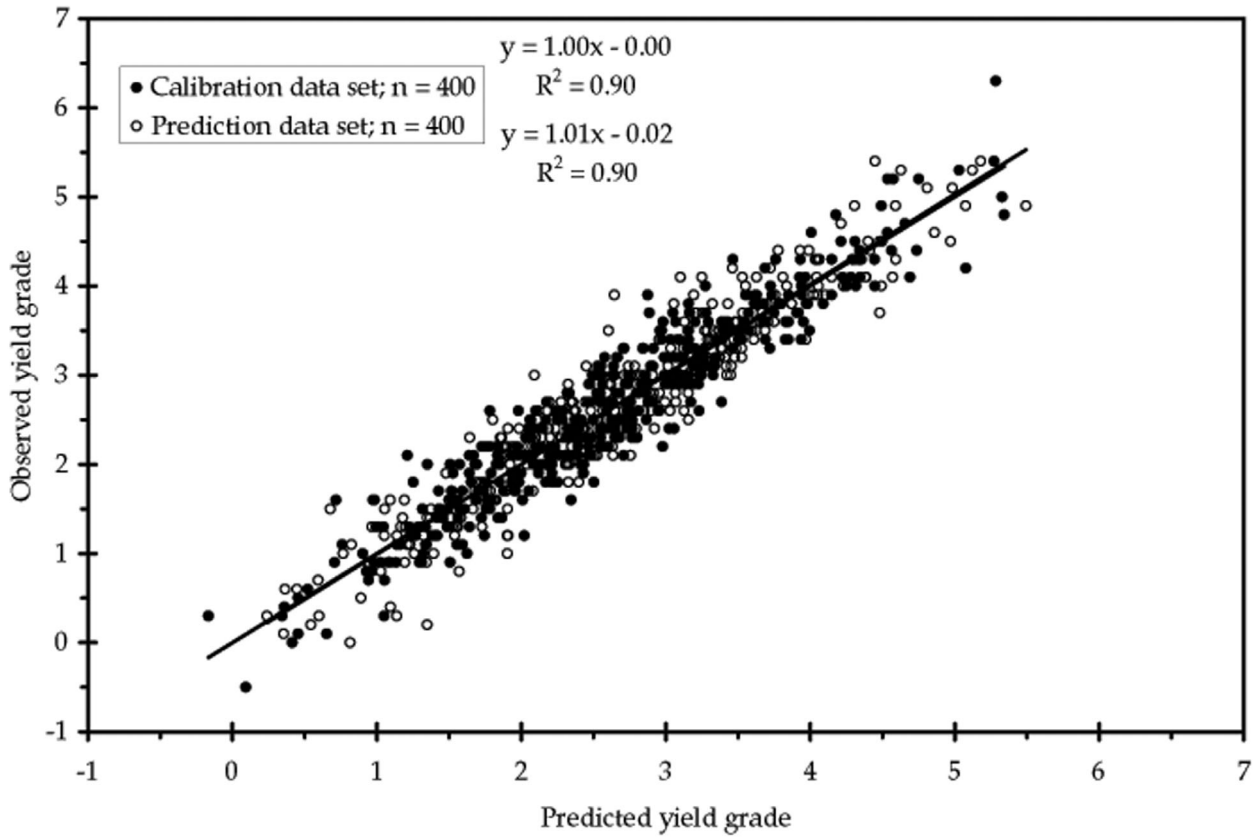

FIGURE 1. *Use of image analysis and hot carcass weight to predict yield grade.*

pears that yield grade can be predicted more accurately by the present system than by augmented yield grading.

Prediction of Ribeye Area

A six-variable regression equation that included HCW and image analysis variables accounted for 89% and 87% of the variation in ribeye area in the calibration and prediction data sets, respectively (Figure 2). A five-variable regression equation that included only image analysis variables accounted for 88% and 85% of the variation in ribeye area in the calibration and prediction data sets, respectively.

Prediction of Adjusted Preliminary Yield Grade

A five-variable regression equation that included HCW and image analysis variables accounted for 88% of the variation in adjusted preliminary yield grade in both the calibration and prediction data sets (Figure 3). A six-variable regression equation that included only image analysis variables accounted for 88% of the variation in adjusted preliminary yield grade in both the calibration and prediction data sets.

Prediction of Marbling Score

An eight-variable regression equation that included only image analysis variables accounted for 74% and 73% of the variation in marbling score in the calibration and prediction data sets, respectively (Figure 4). Although the proportion of variation in "expert" marbling scores accounted for by this system is greater than that accounted for by CVS (66%; Steiner et al., 2000) or VIAscan™ (49%; Steiner et al., 2000), this system is not accurate enough to be used for USDA quality grading. The mean absolute error was 41% of one degree of marbling and marbling score was mispredicted by more than one marbling degree for 6.9% of the carcasses.

Implications

The technology described herein could be used by the beef industry to accurately predict beef yield grades. Use of this image analysis system should help facilitate value-based beef marketing.

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Disclaimer

Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the stan-

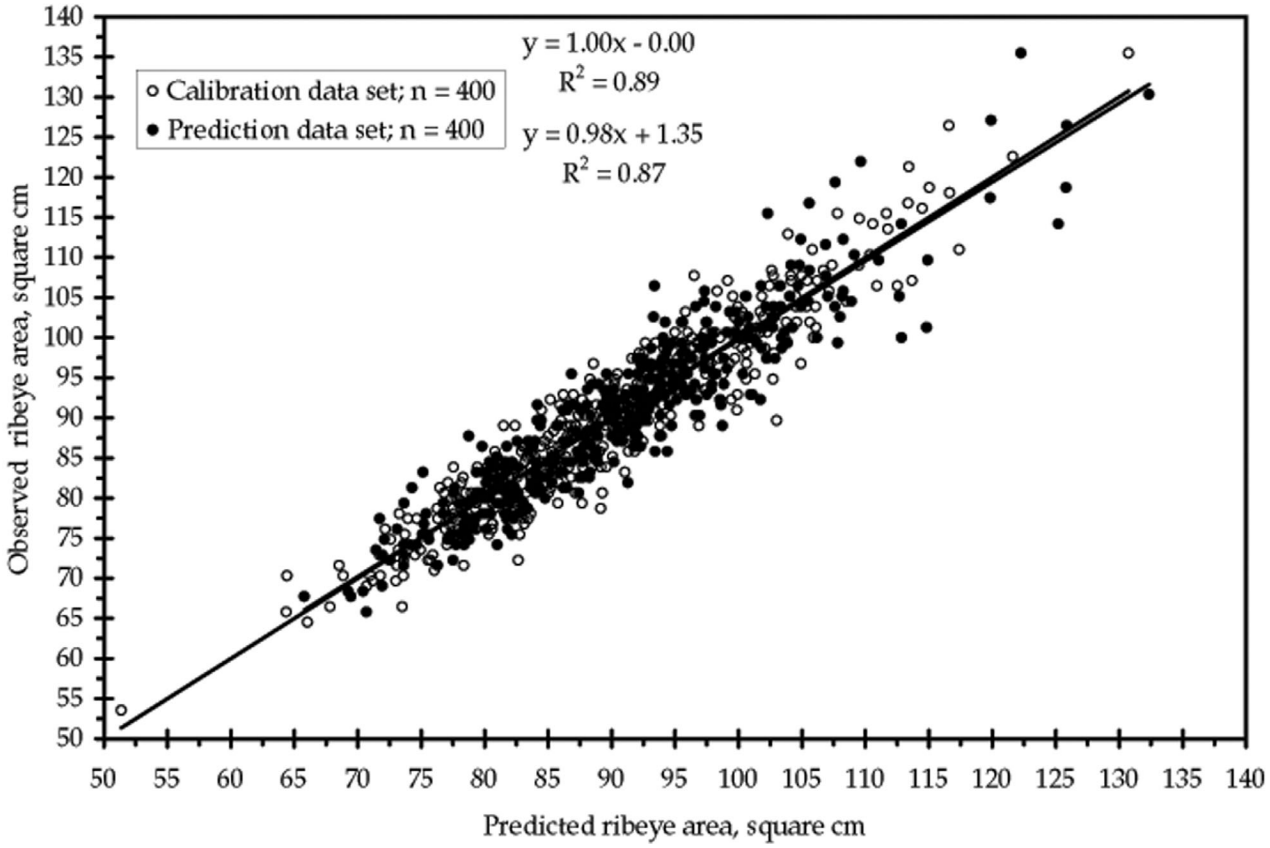

FIGURE 2. *Use of image analysis and hot carcass weight to predict ribeye area.*

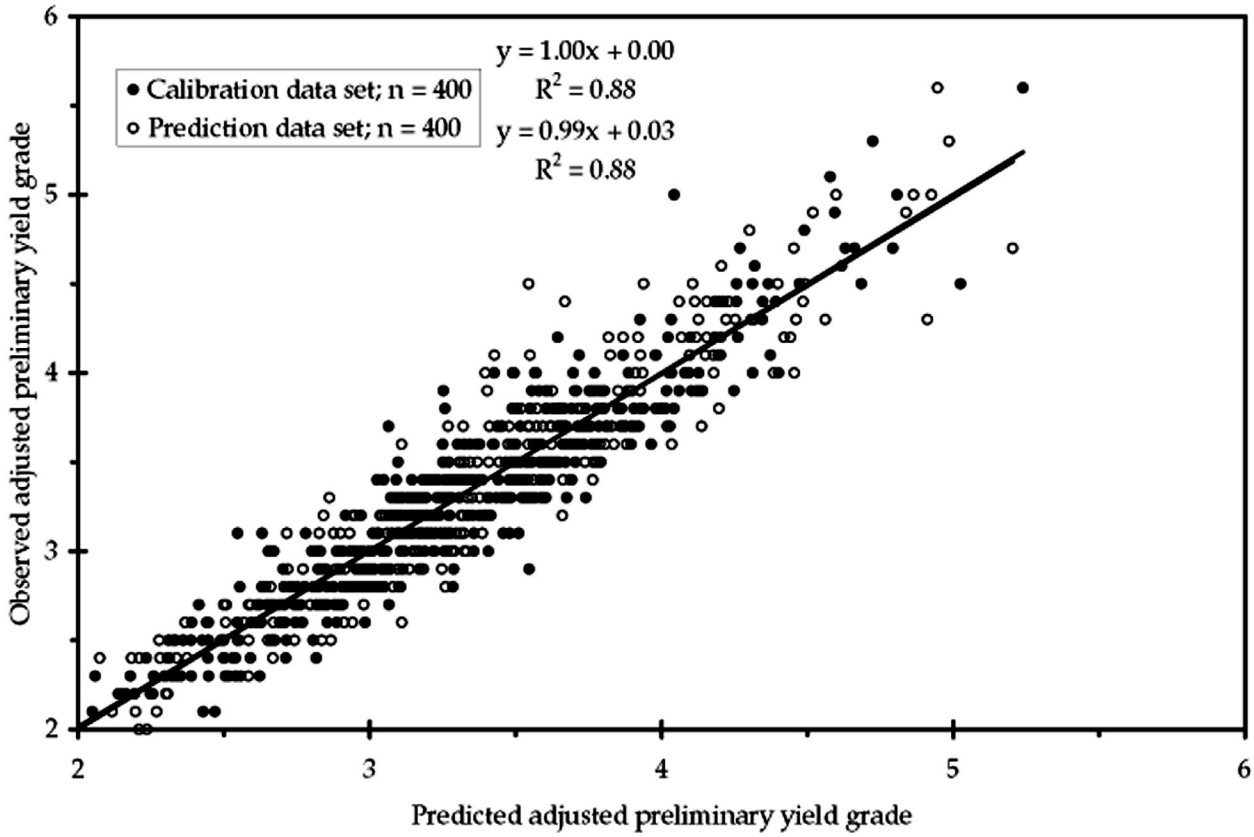

FIGURE 3. *Use of image analysis and hot carcass weight to predict adjusted preliminary yield grade.*

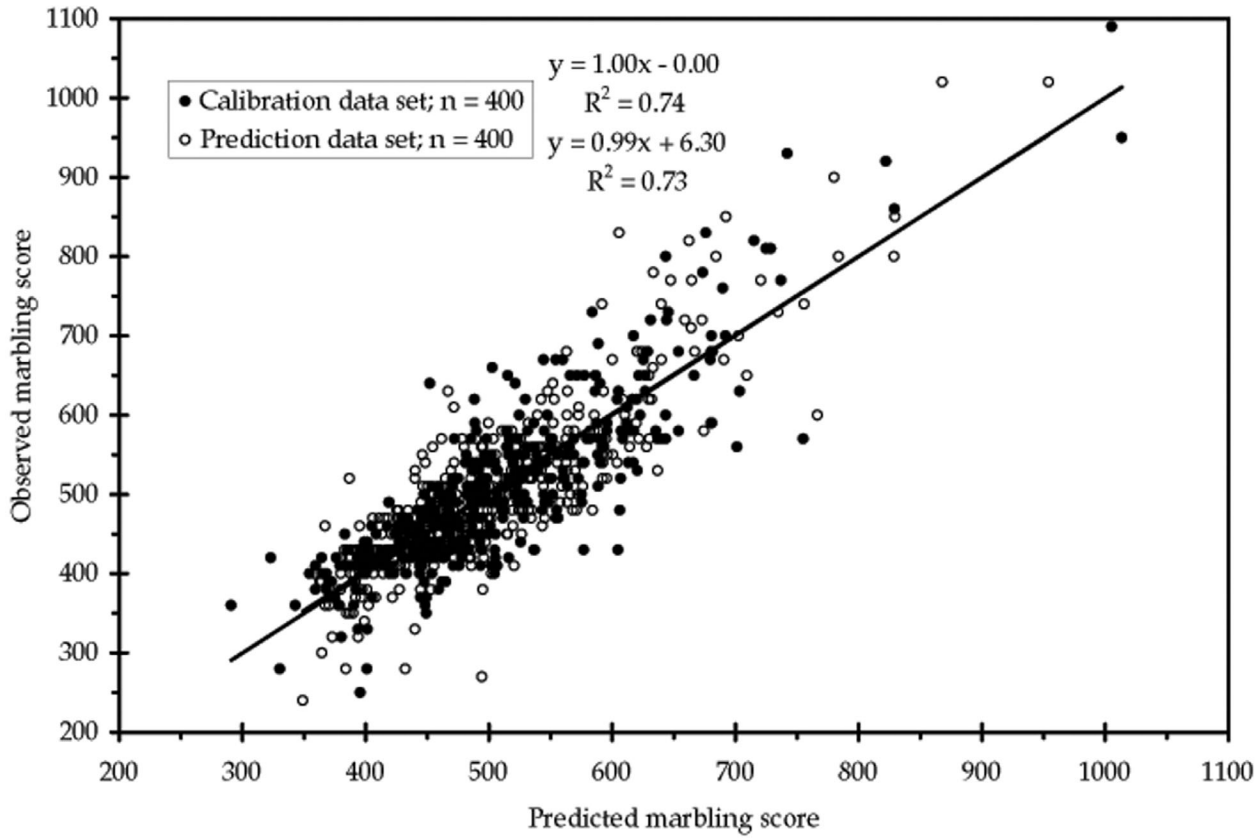

FIGURE 4. *Use of image analysis and hot carcass weight to predict marbling score. 200 = Practically Devoid⁰; 300 = Traces⁰; 400 = Slight⁰; 500 = Small⁰; 600 = Modest⁰; 700 = Moderate⁰; 800 = Slightly Abundant⁰; 900 = Moderately Abundant⁰; 1000 = Abundant⁰.*

dard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of other products that may also be suitable.

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