

Accuracy and Repeatability of Beef Carcass Ribeye Area Measurements for the Application of Augmented USDA Yield Grades

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SUMMARY

This study was conducted to determine the accuracy and repeatability of ribeye area (REA) measurement. Beef carcass sides (N = 100) were independently assigned REA via the plastic grid method by expert USDA graders, line graders, and via polar planimeter measurements. Two VIA systems (Canadian CVS) assigned REA measurements independently, while carcasses were either stationary or in-motion (on an automated grading chain). Accuracy of instrument measurement of REA was accurate compared to those of expert graders using stationary procedures ($R^2 = .97$ to $.98$), or when measured in-motion ($R^2 = .96$ to $.97$). Moreover, VIA instrumentation achieved levels of repeatability higher than those of expert graders.

KEY WORDS: Accuracy, Repeatability, Ribeye area, VIA.

INTRODUCTION

At present, USDA line graders estimate visually the extent to which ribeye area meets or deviates from a prescribed “expect” value (based upon the “schedule” depicting the relationship between ribeye area and hot carcass weight), and then express such quantification in Yield Grade units (e.g., 0YG, -.3YG, +1.2 YG, etc) for use in computing final Yield Grades for beef carcasses. If the line grader desires greater accuracy in assessing ribeye area, a plastic grid (or a ribeye tracing and subsequent measurement of area using a compensating polar planimeter, in rare cases) can be used to obtain an objective measurement of the area of the exposed surface of the *longissimus dorsi* muscle at the 12th/13th rib

interface. The amount of variance associated with use of the plastic grid technique, among differing individuals obtaining the ribeye area measurement or among differing replications of measurement on the same beef carcass ribeye, for purposes of establishing a “standard” ribeye area measurement is currently not well documented. Thus, at present, no data exist regarding the accuracy or repeatability of either grading supervisors or line graders in measuring ribeye area of beef carcasses using a plastic grid, making it impossible to quantify comparative expectations of expert graders, line-graders and instruments with regard to either accuracy or repeatability of their estimates.

Instrument assessment of ribeye area can be used to augment application of USDA Yield Grades to beef carcasses; previous studies (Belk et al., 1998; Canell et al., 1999; Wyle et al., 2000) have shown instrument assessment of ribeye area to be highly correlated with expert “Gold Standard” ribeye area measurements. However, no studies have been done on the repeatability of instrument estimation of ribeye area. Consequently, a baseline for accuracy and repeatability of ribeye area estimation is needed if instruments are going to be introduced for commercial use in augmenting federal USDA Yield Grades.

Therefore, the objectives of this study were to determine the amount of variance that occurs among ribeye area measurements that are obtained by experts, line graders, and instruments; determine standard of performance in addition to operational standard of performance for accuracy and repeatability of an instrument that is used to measure the ribeye area of beef carcasses; and to ascertain if the repeatability of ribeye area measurements derived via instrumentation is equal to or better than the repeatability of experts, and line-graders when ribeye area is measured either using the plastic grid method or by tracing the ribeye and subsequently measuring the area via use of a compensating polar planimeter.

MATERIALS and METHODS

Fifty carcasses were selected randomly from normal production on a commercial packing plant ribbing chain by Colorado State University (CSU)

personnel, both sides of the carcasses (50 left sides and 50 right sides) were used in this study (N = 100). Selected carcasses exhibited a wide range in weight and ribeye area (REA).

Acetate Paper Tracing and Planimeter Measurement Method

Following carcass selection three trained CSU personnel using acetate paper obtained three separate and independent tracings of each exposed ribeye. Ribeye area tracings were collected in a confidential manner by CSU personnel. After completion of data collection, each set of three tracings for each carcass ribeye was measured using a compensating polar planimeter, by three separate and independent CSU personnel (each measuring one of the three different ribeye tracings for each carcass) to determine planimeter ribeye area.

Plastic Grid Measurement Method

Upon the completion of acetate paper tracing of ribeyes, three expert USDA graders separately and independently measured the ribeye of each carcass (n = 100) via the plastic grid method prior to the first, second, and third circulations of carcasses past the grading stand. CSU personnel recorded Ribeye area measurements in a confidential manner. After the third circulation of carcasses past the grading stand, three USDA line graders separately and independently measured the ribeye of the left sides only (n = 50) via the plastic grid method. Ribeye area measurements were recorded in a confidential manner by CSU personnel.

Procedure 1:

Static Instrument Triple Trigger Measurement Method

Each carcass was immediately evaluated after the first plastic grid measurement. While at a stationary position in a re-grade bay, two portable RMS Computer Vision Systems (CVS) operated by two different operators obtained three sequential but separate images by properly placing the camera head unit over the 12th/13th rib interface without moving the camera head unit between images for both sides of each of the 50 carcasses (for a total of 100 carcass sides x 3 replicates per ribeye = 300 observations for each of the two different portable CVS systems).

Procedure 2:

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Static Instrument Placement Measurement Method

Following the Triple Trigger Measurement and prior to the first circulation of carcasses by the grading chain, two portable CVS systems operated by two different operators obtained static placement ribeye area measurements by positioning the camera head unit over the 12th/13th rib interface, obtaining one image, removing the camera head unit, returning the camera head unit to the ribeye interface, obtaining a second image, removing and returning the camera head unit, and obtaining a third image (for a total of 100 carcass sides x 3 replicates per ribeye = 300 observations for each CVS system).

Procedure 3:

On-Line Instrument Measurement Method

After the completion of the static measurements, each carcass side was circulated three times, among a group of carcasses on a automatic grading chains, across the grading stand at operational chain speed (360 head/hour) where the two portable CVS instruments obtained the images of the ribeye at the 12th/13th rib interface (for a total of 100 carcass sides x 3 circulation = 300 observation for each CVS system), pausing between each circulation for the experts to again independently measure, via the plastic grid, the actual ribeye area of each designated carcass side.

STATISTICAL ANALYSIS

The simple average (mathematical mean) of the three independent measurements of the ribeye area of a carcass obtained by experts, and the average of the three independent tracings were defined as the “actual” measures of ribeye area. Accuracy of instrument estimate of the ribeye area for a given carcass was assessed by comparing each instrument estimate to the appropriate “actual” ribeye area measures for that carcass and determining the strength of the relationship by use of correlation/regression analyses.

Repeatability of instrument estimates of ribeye area for a given carcass was assessed by determining the differences among the three ribeye area estimates in each set (of three) images obtained during conduction of the static

and on-line procedures of the study. These repeatability estimates were contrasted with repeatability estimates determined by comparable analyses among estimates of the three experts and estimates of the line graders using the plastic grid method. In addition, instrument repeatability was compared for the static procedures with the results of acetate tracing and subsequent measurement with a compensating polar planimeter.

RESULTS and DISCUSSION

Coefficient of determination (R^2) and residual standard deviation used for accuracy determination of procedures 1, 2, and 3 are presented in Table 1. The triple trigger method (Procedure 1) was highly accurate in assessing REA, explaining 97% and 98% of the observed variability in mean expert gridded REA, and mean acetate traced REA, respectively. The very low unexplained variation by the triple trigger method (RSD = 0.13 to 0.15) indicate a high level of precision by both of the VIA systems, revealing that on average the VIA measured REA was off by a very small margin of thirteen to fifteen hundredths of an inch from the expected measurement, or less than a tenth of a Yield Grade.

The Placement method (Procedure 2) exhibited accuracy levels ($R^2 = 0.97$ to 0.98) identical to those of the triple trigger method, explaining almost all of the observed variability in mean expert gridded REA, and mean acetate traced REA. The residual standard deviation for the placement method (RSD = 0.11 to 0.13) exhibited a slightly higher level of precision than that of the triple trigger method. This was not expected, since more variability was introduced on this procedure due to the removal and placement of the VIA camera from the 12th/13th rib interface.

As expected the on-line method (Procedure 3) had a slightly lower level of accuracy ($R^2 = 0.96$ to 0.97) than the stationary methods (Procedures 1 and 2), but it was still extremely accurate, explaining most of the exhibited variability by the expert plastic grid method, and by the tracing method. The on-line precision (RSD = 0.08 to 0.12) was also extremely high, causing a marginal error of only five hundredths of a Yield Grade on average.

Repeatability results for procedures 1, 2 and 3 are shown in Table 2. The

triple trigger method (Procedure 1) exhibited the highest level of repeatability by missing the average expected REA value by only eight hundredths of an inch. The triple trigger method expressed repeatability levels much higher than those of expert grid measurements, and that of the tracing method. Triple trigger standard deviation, indicates that 95% of the VIA REA measurements were within 0.24 inches of the expected mean, or just a tenth of a Yield Grade off. This represents a much lower level of variability than when compared to expert grid measurements and the tracing method (SD = 0.19 and 0.33, respectively).

As previously indicated, the removal and placement of the VIA camera from and to the 12th/13th rib interface introduced a greater level of error to the ribeye area measurements taken by the VIA cameras. Therefore, the repeatability of the placement method (Procedure 2) was marginally lower than that of the triple trigger method (Procedure 1). Nonetheless, the repeatability of the VIA placement method (Mean absolute difference = 0.13) was still considerably higher than that of the expert plastic grid method (Mean absolute difference = 0.20), and considerably higher than that of the tracing method (Mean absolute difference = 0.19). VIA placement standard deviation, revealed that approximately 95% of the VIA placement REA measurements were within 0.34 inches of the mean, which was a great improvement when compared to the tracing method (SD = 0.33).

The on-line VIA measurement method (Procedure 3) resulted in the lowest repeatability levels (Mean absolute difference = 0.29), as well as, the greatest variability levels (SD = 0.33) when compared to procedures 1, 2, expert plastic grid method, and the tracing method. However, on-line results are still very acceptable. The lower levels of repeatability, in addition to the higher levels of variability in REA measurements can be attributed to the fact that REA measurements for procedure 3 were obtained in an operational environment, which was not as pristine as the environment in which procedures 1, 2, the expert grid method, and the tracing method were conducted. Moreover, in an operational

environment such as in procedure 3, operator efficacy in obtaining a correct placement of the VIA camera over the 12th/13th rib interface was reduced due to the fact that beef carcasses were presented for analyses while moving on the automated grading chain, thus reducing the operator ability to obtain a precise placement of the camera over the 12th/13th rib interface.

IMPLICATIONS

Ribeye area measurements derived via instrumentation in both a stationary position and in an operational scenario are highly repeatable and accurate when compared to measurements derived from expert grid measurements and acetate traced/polar planimeter readings. This indicates that instruments can be used to measure ribeye area if VIA instrumentation were introduced to augment the application of USDA Yield Grades to beef

carcasses. Furthermore, these results provide information that was not previously available for use in testing/authenticating performance standards for accuracy and repeatability of instrument ribeye area measurement. Ribeye area measurement is one of the most important factors included in the determination of federal USDA Yield Grades of beef carcasses, and the correct assignment of USDA Yield Grades are vital for all segments of the industry. Therefore, instruments can play a key role in strengthening the relationship between producers, feeders, packers, and consumers, while at the same time assisting the beef industry to become more value driven.

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Table 1. Accuracy: Global coefficients of determination (R²) and RSD values for the overall mean expert gridded REA for all circulations, the overall mean acetate planimeter REA for each carcass side, and the overall mean VIA REA measurements (for two systems combined) by procedure.

Measurement Method	Mean VIA Ribeye Area Measurements					
	Triple Trigger ^a (Mean of 600 images)		Placement ^b (Mean of 600 images)		On-Line ^c (Mean of 600 images)	
	R ²	RSD	R ²	RSD	R ²	RSD
Mean Expert Gridded REA ^d	0.97	0.13	0.97	0.13	0.96	0.12
Mean Acetate Traced REA ^e	0.98	0.15	0.98	0.11	0.97	0.08

^aTriple Trigger: Average of three sequential images of the 12th/13th rib interface by two VIA cameras = 6 total VIA readings/ribeye, without moving the camera head unit between images.

^bPlacement: Average of three images of the 12th/13th rib interface by two VIA cameras = 6 total VIA readings/ribeye, removing the camera head unit and replacing it between images.

^cOn-Line: Average of three images of the 12th/13th rib interface by two VIA cameras = 6 total VIA readings/ribeye, at commercial chain speeds (360 head/hr).

^dMean Expert Gridded REA: Average of three grid measurements by three expert graders per ribeye = 9 total grid measurements/ribeye.

^eMean acetate traced REA: Average of three tracings by three planimeter readings per tracing = 9 total planimeter readings/ribeye.

All correlations differ from zero ($P < .0001$).

Table 2. Repeatability: Mean absolute difference and standard deviation values for the mean gridded REA measurements by circulation (N = 300), the overall mean acetate planimeter REA readings (N = 900), and the mean triple-trigger, placement, and on-line VIA REA measurements by procedures 3, 4 and 5 (N = 600).

Measurement Method	Mean Absolute Difference ^a	SD
Circulation 1 Expert grid REA ^b	0.22	0.23
Circulation 2 Expert grid REA	0.18	0.13
Circulation 3 Expert grid REA	0.19	0.17
Overall Expert grid REA ^c	0.20	0.19
Overall Tracing REA ^d	0.19	0.33
Procedure 1:		
Camera 1 Triple Trigger ^e	0.06	0.10
Camera 2 Triple Trigger	0.09	0.14
Overall Triple Trigger	0.08	0.12
Procedure 2:		
Camera 1 Placement ^f	0.14	0.20
Camera 2 Placement	0.12	0.13
Overall Placement	0.13	0.17
Procedure 3:		
Camera 1 On-Line ^g	0.21	0.21
Camera 2 On-Line	0.38	0.40
Overall On-Line	0.29	0.33

^aMean Absolute Difference: absolute difference of individual measurements from the average of those same measurements.

^bCirculation 1 Expert grid REA: Average of three grid measurements per ribeye by three expert graders for circulation 1 (N = 300).

^cOverall Expert grid REA: Average of three grid measurements per ribeye by three expert graders for all circulations (N = 900).

^dOverall Tracing REA: Average of three planimeter readings per ribeye by three tracers (N = 900).

^eCamera 1 Triple Trigger: Average of three sequential images per ribeye, of the 12th/13th rib interface by camera 1, without moving the camera head unit between pictures during procedure 1.

^fCamera 1 Placement: Average of three images per ribeye, of the 12th/13th rib interface by camera 1, removing the camera head unit between images.

^gCamera 1 On-Line: Average of three images per ribeye, of the 12th/13th rib interface by camera 1, at commercial chain speeds (360 head/hr).